The Journal of

THE AUSTRALIAN INSTITUTE OF AGRICULTURAL SCIENCE

Registered at the G.P.O., Sydney, for transmission by post as a periodical.

Editor :
H. J. HYNES, D.Sc.Agr., M.Sc.
Address : Box 3819T, G.P.O., Sydney, N.S.W.

Assistant Editor :
L. S. CAYZER, M.Sc., B.Sc.Agr.

Sub-Editors :
F.C.T.—G. A. CURRIE, D.Sc., B.Sc.Agr. ; *Vic.*—F. S. CRAWFORD, M.Agr.Sc.
S.A.—H. C. TRUMBLE, M.Agr.Sc. ; *Q'land.*—J. H. SMITH, M.Sc., N.D.A.
W.A.—L. J. H. TEAKLE, Ph.D., B.Sc.Agr. *Tas.*—J. W. EVANS, M.A.

Business Manager :
E. T. EDWARDS, M.Sc.Agr.
Address : Box 3819T, G.P.O., Sydney, N.S.W.

Literary matter for publication should be in double-spaced typescript, and should be forwarded to the nearest member of the editorial committee. Original papers must not be unduly long, and tables and photographs should be reduced to a minimum. All contributions must be lodged with the Editor not later than the first day of February, May, August, or November. Orders for reprints should accompany MSS.

VOL. 3, No. 1 MARCH, 1937

After Two Years

With the close of the first two years of the life of the Institute, culminating in the General Meeting held in Sydney last January, the record of progress and achievement in so brief a span may be viewed with a sense of satisfaction and pride which is in every way amply justified. Even if the total corporate and student membership of 351 and the bank balance of some £340 as at December 31, 1936, were the only foundations for self-congratulation, the Institute might well present a smiling face, for at the Inaugural Meeting in Melbourne in 1935 no one in his most optimistic mood dared predict an enrolment of more than 150 and a substantial monetary reserve in the first year or two. But there have been advances along other lines as well : through the establishment of strong and active Branches in the seven centres of the Commonwealth members have been able to meet regularly and participate in discussions of agricultural importance, and in this way have been able to make direct or indirect contributions, however small as yet, to the advancement of the national welfare, which

is at once a primary function of our professional organization. The recognition accorded at various times to the utterances of many members occupying high places throughout Australia is itself indicative of the strength of the personnel of the Institute, and the valuable part being played by agricultural scientists in the community life. The extensive mention given in reports and leading articles in the daily and weekly Press to Professor Richardson's Presidential Address at the first general meeting furnished further convincing proof of its broad national character and importance, and incidentally brought the Institute before the notice of a general public to whom the profession of agricultural science was previously an unknown quantity.

In the publication of the quarterly Journal, now enlarged from 44 to 60 pages in each issue, there has been further evidence of activity and progress. To some it has been the long-desired medium for the publication of informative general articles and statements of a technical character ; to others it has been the tangible expression of the existence of our professional group ; but to everybody connected in any way with the Institute and its activities the Journal has been the main connecting link between members and Branches scattered throughout the Commonwealth, without which the bond of union so manifestly strong at present would doubtless have taken years to develop. In this and in all other phases of the Institute's work there has been displayed by all concerned that degree of enthusiasm, effort and co-operation so necessary for success in the early years of a new institution. Through the untiring energies of our first President, the Secretary, the Treasurer, Executive and Journal Committees and Branch Executives, the foundations of the Institute have been firmly laid, while the spirit of co-operation on the part of members generally is more than suggestive of their desire to see the profession grow in strength and usefulness year by year.

The original draft of the Constitution has, as might have been expected, undergone numerous changes, and the new—and, to be hoped, final—draft of the Memorandum-Articles of Association resulting from full discussion at the general meeting should now be acceptable to one and all. The biennial election of office-bearers resulted in the return of former executives, with Professor S. M. Wadham as the new President. Thus with every confidence may we enter upon our third year, fully expecting that by the time of the second general meeting two years hence, the Institute of Agricultural Science will be in even a stronger and more influential position than it is at present.

PRESIDENTIAL ADDRESS

By

A. E. V. Richardson, M.A., D.Sc.,

Professor of Agriculture and Director of the Waite Agricultural Research Institute, University of Adelaide, South Australia.

(*Delivered to the Australian Institute of Agricultural Science at its First General Meeting, held at Science House, Sydney, on January 6, 1937.*)

Barely two years have elapsed since delegates from the various agricultural scientific organizations met in Melbourne to create a new institution to serve the needs of agricultural workers in Australia—the Institute of Agricultural Science.

The progress of the Institute during the past two years has been extremely gratifying, and beyond the anticipations of those who were responsible for its creation. On December 31, 1936, the number of members registered was no less than 351.

Of more importance, however, than mere numbers is the fact that active Branches have been firmly established in all States of the Commonwealth and in the Federal Capital Territory, and that these Branches are functioning most efficiently. The discussion of problems of general interest to agricultural scientists, and of particular importance to the State or territory in which the Branches are located, has been a feature of the meetings. The general result of these discussions must ultimately be to promote the advancement of agricultural science and further the interests of agriculture in the Commonwealth, and so achieve one of the main objectives of the Institute.

The Institute of Agricultural Science differs from most other professional organizations, in so far as the great majority of its members do not engage in the practice of their profession and receive payment for their services on a consultative basis, as is the case with their colleagues in the field of medicine, law, architecture, dentistry, etc., but they work under a socialized scheme of public service in the various Departments of the State and the Commonwealth. The work of its members lies almost wholly in providing services to the community through research into the facts and principles that underlie the most fundamental industry of mankind, and in the application of those facts and principles to keep pace with the demands of an ever-advancing civilization. It is probably true that the majority of men engaged in the profession of agricultural science do not receive as payment for their services salaries commensurate with the incomes of their professional colleagues in other spheres, or with the incomes of the business men who exploit the products of agriculture. Nevertheless, I cannot avoid the conviction that the rewards

of professional men in the sphere of agricultural science must in due course be commensurate with the high educational attainments and intensive training now demanded of specialists in the profession. It is becoming clear that governments must and will look increasingly in the future to their agricultural scientists for constructive leadership and wise counsel in the conservation and development of the agricultural and pastoral resources on which the material welfare of the nation is so largely based.

THE PIONEERS OF AGRICULTURE.

It is perhaps appropriate at this, the first general meeting of the Institute, to refer briefly to the debt we owe to the pioneers who laid the foundations of our agricultural industries on a sound basis. Much of the progress in the agricultural and pastoral industries since the establishment of the first settlement nearly 150 years ago has been due to the resourcefulness and rugged individual initiative of a long line of pioneers. These men, with comparatively few resources at their disposal, with few helpers and no dearth of critics, had not only to forge the machinery to serve agriculture, but also had to overcome the ignorance and prejudice of their day and generation.

Of those who, by their forethought, energy and perseverance, laid the foundations of the wool industry, the list is long and honourable, and includes men in every State of the Commonwealth, but outstanding among these was John Macarthur, who was the first to visualize the possibilities of producing Merino wool in Australia. He imported Merino sheep from Cape Colony in 1796, and improved these by importations in 1805 of Merino rams from King George's own flocks. The Society of Arts of London in 1822 awarded him two medals, one for having exported to London 150,000 lbs. of fine Merino wool, and the other for bringing his wool up to the standard of the best Saxon Merino. At Camden Park, the descendants of the original flock of Spanish Merinos may be seen, and these afford a striking contrast to the modern Merino flocks in Australia, showing the extraordinary change in size and constitution of the sheep and in the density of staple brought about by successive generations of skilled breeders. Macarthur's genius as a sheep breeder, and his gift of the Merino sheep to his country place him in the highest rank among the pioneers and founders of Australia.

To the pioneer pastoralists who blazed the trail and opened up large areas of pastoral country, Australia owes a debt of gratitude. These men needed not only considerable capital, but also resourcefulness, capacity for endurance, and that enterprising spirit which led them to combat, in areas far removed from the borders of settlement, the risks of disease, bush and grass fires, dingoes, marauding natives, and worst peril of all—drought.

Apart from all these risks which are inherent in the pastoral country, there were those due to the low price of sheep. When once the country was fully stocked, there was practically no means of disposing of the surplus, and

early records abound with instances in which sheep were of little value save for boiling down for their tallow. The application of the principle of refrigeration to the transport of perishable produce by Thomas Sutcliffe Mort, the founder of Mort's Dock, Sydney, in the seventies of last century, completely changed the outlook of the pastoral industry. Mort took up a farm at Bodalla in 1856, and this farm had a great influence on the development of dairying in Australia. In 1870 he began a series of experiments in Sydney on the freezing and thawing of meat, with a view to the transport of meat to England. Just as his cherished idea of sending frozen meat abroad was realized, Mort died on his Bodalla farm in 1878. By his pioneer work, however, the meat industry and the dairy and fresh fruit industries were placed on a sound export basis.

Prominent among those who have had a marked influence on the development of the wheat industry was John Ridley, of South Australia, who in 1843 invented the stripper, which led to a marked lowering of the cost of harvesting and made possible the establishment of the wheat industry on an export basis. The thanks of Parliament were conveyed to Ridley in December, 1858, in recognition of the benefits the colony of South Australia had derived from the reaping machine. The basic principles underlying Ridley's invention were used in all subsequent harvesting machines, but were applied in a most ingenious manner by H. V. McKay, of Victoria, in the development in 1884 of the complete harvester, and its successor, the auto-header.

The invention of the stump-jump plough by R. B. Smith, of Ardrossan, South Australia, in 1876, made possible the economic exploitation of large areas of mallee country in Australia, and led to a substantial increase in acreage under wheat. So much importance was attached to the invention of the stump-jump plough that the Parliament of South Australia made a substantial grant of land to Smith in recognition of his services to the community.

A tremendous impetus was given not only to wheat production, but to most of the agricultural industries in Australia, by the demonstration by Professors Custance and Lowrie, of Roseworthy College, of the value of superphosphate, in the eighties of last century. Lowrie, amid great initial opposition and prejudice on the part of the farmers, vigorously advocated the use of the long bare fallow and liberal dressings of superphosphate for wheat, and after a quarter of a century of intensive effort succeeded in securing the general adoption of both practices in South Australia. The general adoption of these sound principles led to a remarkable development of the wheat industry, and made possible its extension to drier and poorer lands.

The production of improved varieties of wheat adapted to the soil and climatic conditions in the various portions of Australia has been an important factor in developing wheat production. The pioneer worker in this field was William Farrer, who began his self-appointed task in 1886. He proved to be

the outstanding wheat breeder of Australia, and workers came from other countries to study his methods. Through his untiring efforts the varieties of wheat were greatly improved in yield, milling quality, drought resistance and rust resistance, and his many creations resulted in a large increase in the annual wheat harvest of Australia. Probably no future wheat breeder will have the opportunity of effecting such a revolutionary change in wheat production as Farrer, because of the substantial improvements made, not only by Farrer himself, but also by the contemporaries whom he inspired, e.g. Marshall of South Australia, and Pye of Victoria, and by those who were associated with him in the later stages of his work.

In the field of agricultural and dairying education, an outstanding personality was H. W. Potts, a former Principal of the Hawkesbury Agricultural College. He was largely responsible for the organization at Hawkesbury of a school of dairy instruction that has had more influence on dairy practice and manufacturing technique than any other in Australia. He was a prominent educationist of his generation, with an unusual flair for extension work in agriculture.

In the field of botanical science and its application to the study of Australian flora, and particularly of exotic species suitable for growth in Australia, the work of Baron von Mueller, formerly Government Botanist of Victoria, was outstanding. Not the least interesting and useful of his many contributions was the introduction of the South American grass *Paspalum dilatatum*, which has transformed the coastal areas of Eastern Australia and made them of unique value for dairying.

In the field of plant pathology was the indefatigable McAlpine, whose classic contributions on the rusts and smuts of Australia made him a world-wide authority on the mycological work of his generation, and an inspiring leader of his branch of science.

Two other pioneers are worthy of mention in this brief record. The one was A. W. Howard (1848-1930), who was the first to recognize the extraordinary value of subterranean clover, and to cultivate it extensively on his property at Mt. Barker, in South Australia. This plant has had a remarkable influence on the improvement of pastures in the winter rainfall region of Australia.

The other was one of the pioneers of modern irrigation, George Chaffey, who, with his brother William, was induced by Alfred Deakin to come to Victoria. They selected Mildura in 1884, and were granted 50,000 acres of land by the Victorian Government in 1887. After many initial difficulties, the enterprise emerged successfully, and has since become an outstanding example of the value of irrigation as a means of fostering closer settlement.

The establishment of the Colleges of Agriculture—Roseworthy (1882), Dookie (1885), Hawkesbury (1888), Gatton (1895), Muresk (1926)—to provide

instructional work in agriculture and promote more scientific methods of agriculture, stock husbandry and dairying, were milestones in agricultural history, but these institutions had to overcome much opposition and prejudice before they won the widespread recognition they now enjoy in the agricultural community.

The establishment of Chairs of Agricultural Science in the various Universities of Australia, which followed much later, paved the way for the training of research workers, teachers and extension workers to serve the ever-growing needs of intensive agriculture.

The establishment in 1926 of the Council for Scientific and Industrial Research, whose main activities have hitherto been directed to research on problems associated with the agricultural and pastoral industries, was a recognition by the Commonwealth Government not only of the importance of agriculture in national welfare, but of the necessity for its intensive development by the aid of scientific research.

PROBLEMS AHEAD OF AGRICULTURE.

To the pioneers who laid the foundations of agriculture so securely we are duly grateful. We must not, however, over indulge in retrospect, for the problems which lie ahead will tax the best talent of which this generation is capable if they are to be successfully met, and if the advance of knowledge is to keep pace with the demands of an advancing civilization. To obtain the right perspective, however, it is essential that the problems should be viewed in relation to the epoch-making changes that have occurred in other fields of endeavour.

In many ways we are living in perhaps the most remarkable epoch that mankind has yet witnessed—an age of revolutionary progress based upon science—an age in which the material progress that used to be spread over many generations, or even centuries, now occurs within the lifetime of a single individual. This progress has been most marked in the manufacturing industries, where the application of physical and chemical science, together with labour-saving machinery, has revolutionized production.

In the field of agriculture there has been an amazing increase in efficiency, especially in the newer agricultural countries, where modern developments in transport, refrigeration, labour-saving machinery, combined with improved technique in production, have enabled these countries to flood the world markets with agricultural products, and threaten the stability of the peasant systems of farming practised in the older countries of the world.

The epoch-making importance of these changes resulting from the scientific progress of the past generation, and their impact on the economic structure of the world, is not yet fully realized.

(1) Ever since the rise of the modern industrial system the supply of raw materials and commodities has in general lagged behind demand. There were in the past occasional, temporary and local gluts, but generally speaking there was a doubt as to whether the supply of foodstuffs and raw materials could be made to keep pace with the growth of population. Now supply, broadly, for the first time over a wide range of commodities has caught up to the demand and, moreover, appears to be capable of meeting any increase in the potential demand. Furthermore, there has been a visible slackening in the rate of increase of world population. The net result is that the age-old problem of scarcity has now been replaced by the problem of abundance, and in many overseas countries restriction of production has been advocated and practised by many governments to maintain the price structure. It was the impact of this change upon the economic system that was largely responsible for the world-wide depression from which we are slowly recovering.

(2) The impact of these changes on the social structure of nations is also worthy of note. In most European countries the peasant is the predominant element of the population, and agriculture is the basis of all other industries. It has been necessary for the State at all costs to protect the peasant structure and to prevent a rate of progress that would drive the family farmer off the land. As Sir Daniel Hall stated recently, the rise of the doctrine of economic self-sufficiency in Europe is fundamentally an attempt to preserve the existing social structure of the State—threatened by the increased production that has resulted from science and invention. The influx of cheap commodities into these countries has therefore been prevented by fantastically high tariff walls, restrictions and quotas, which have thoroughly throttled international trade.

(3) The impact of these changes on the problems of migration and settlement is no less important. The statesmen who framed the Empire Development Policy, which culminated in the Empire Settlement Act, 1922, and the so-called £34 Million Agreement, 1925, thought that the major problems of redistributing the population of the Empire were men and money. At the time the policy was developed, the economic conditions were most favourable for promoting a strong flow of settlement from the United Kingdom to the overseas dominions. There was an extraordinary demand for foodstuffs and raw materials to replace the wastage due to war and to the enormous losses of man power in Europe. There was at that time absolutely no difficulty in regard to markets. Furthermore, it was assumed that it was unnecessary for the new settlers to be trained in the most economic methods of production. The demand for agricultural commodities and raw materials appeared to be so strong that grandiose schemes to promote land settlement and development were freely embarked upon.

Under the £34 Million Agreement, cheap loan money was to be made available for approved schemes of development that would enable the

Commonwealth to receive 450,000 immigrants within ten years. Millions of pounds of loan money were spent in extending the margin of settlement, bringing new lands under cultivation, and in providing the heavy capital expenditure needed for roads, railways and water supply for the new settlers. In pursuit of her policy of stimulating development during the post-war period, Australia borrowed at an extravagant rate, but in 1929 the economic conditions forced her to suspend indefinitely all schemes of assisted migration. Not only did the stream of migration dry up, but during the depression there was actually an outward flow of population.

With returning prosperity, it is certain that the question of migration will again be raised, and it is to be hoped that should the economic conditions in Australia become favourable for migration, there will be no attempt, as before, to transfer people *en masse* to settle in large new communities, but rather that the flow of settlement will be towards land in areas of assured rainfall in which all the capital costs for settlement have already been incurred—in other words, by a policy of infiltration. Moreover, it is eminently desirable that prospective immigrants for land settlement should have had prior experience and training in agriculture. A policy of intensive development in areas of liberal rainfall and proved productive capacity will enable the States to make the most effective use of the capital and man power already engaged upon production, and the most effective use of the assets, railways, water supply, roads and improved land which have been created by the heavy loan expenditure of the past.

Should, therefore, increased demand occur in the future, it would be more economically met by increasing the productivity per acre from existing settled areas than from more extensive cultivation of new land.

(4) Finally, there is the impact of this vastly increased power of production on our own internal economy. According to recent studies of population trends, Britain and many other European countries are approaching a phase of a stationary, and subsequently of a declining population, in which effective demand for agricultural commodities will be lessened not only by mere numbers of consumers, but also by changes in the average age of the population. If these trends are realized, the long-term effect will be a declining demand in our major market for agricultural products accompanied by increased competition from other countries for a contracting market.

These broad facts emphasize the necessity of a more balanced internal economy which will envisage the full development of the mineral, power, forestry, fishery and agricultural resources of the Commonwealth, and the establishment of such manufacturing industries as are dependent upon them.

It will readily be conceded that there is an urgent need for Australia to augment her population more rapidly than is possible by natural increase.

The experience of the past has shown that although the volume of Australian agricultural production has greatly increased during the past three

decades, the increase has not been accompanied by a proportionate increase in rural employment. In New South Wales, for example, the acreage under wheat and the volume of wheat production are approximately three times greater than thirty-five years ago. But though New South Wales has greatly increased the production of wheat and of many other products as well, the numbers employed on the land are not much greater than was the case a generation ago. This is due to the mechanization of production and increased efficiency of production. Increased production from the land, therefore, does not necessarily involve a proportionate increase in rural employment.

Moreover, the prospective markets for primary products are not sufficiently attractive from the long-term viewpoint to encourage the belief that the increased population that Australia needs for security and defence can be obtained by a large increase in primary production.

On the other hand, a feature of the post-war period is the extent to which the secondary industries of Australia have expanded and provided an increasing measure of employment. The further development of worth-while Australian secondary industries along appropriate channels would provide new avenues for employment and a larger home market both for primary and secondary industries. While, therefore, the importance of the secondary industries as a means of increasing employment is stressed, this does not mean that the maintenance and expansion of primary industries is not also of great importance. But what is wanted is a well balanced economy for Australia, with both primary and secondary industries contributing their full share to bring about that progress and prosperity. That is essential for Australia's rapid development.

Having emphasized the importance of a balanced economy, we may now return to the development of the primary industries, in which this Institute is specially interested. There seems to be only one possible course to pursue, and that is to meet the strenuous competition of other countries by the production of high quality goods at the lowest cost.

The need for improving the quality of our products—beef, mutton, lamb, butter, wheat, fruit, wine—will readily be conceded, for Australia must compete in world markets with other exporting countries whose produce is recognized as of high quality, e.g. Argentine beef, New Zealand lamb, Canadian wheat, Danish butter, etc. In this field there is much to be done to raise the quality of our export products to the highest attainable level. But what shall be said regarding the increased production of food and raw materials in a world that has recently been disorganized by an apparent excess of production ? There is no doubt that the channels of distribution and trade have been clogged by the post-war growth of economic nationalism and lack of purchasing power. But the excess of food and raw materials is apparent rather than real, for investigations have shown that many millions of people, even in the richest industrial countries of the world, e.g. United States, Britain and France, are more or less under-nourished, whilst for the countless millions in Europe and

Asia the suggestion of an excess of food and raw materials seems positively grotesque.

The Assembly of the League of Nations recently launched a campaign for better national health through better feeding, by using increased quantities of protective foods such as milk, fruit, dairy products and vegetables in the dietaries of nations. Should the governments of the world decide to improve the dietaries of their nationals as a means of conserving health and efficiency, to say nothing of the value of well nourished citizens for defence purposes, then the outlook for primary production, especially in the newer countries, will be greatly improved.

Apart, however, from any developments which may arise from the improved nutrition of mankind, there is need to give agriculture all the help possible in the reduction of costs and improvement in the quality of our products so that we may be in the best possible position to meet the competition of other countries. The development of scientific research, improved technique in farming, and the further mechanization of agriculture offer means by which more efficient production may be secured, with a consequent lowering of costs. The development of our agriculutral and pastoral industries to the highest attainable limit through research and extension work is therefore essential, if we are to meet the competitionof other countries on a sound economic basis.

RESEARCH AND EDUCATION IN AGRICULTURE.

The experience of all agricultural countries shows that developmental railways, improvement of road transport, extension of irrigation enterprises, and opening up of new markets will aid agriculture, bring new lands under cultivation and develop the country, but something more than this is needed to make agriculture productive and profitable. The agricultural output may be increased by all these methods, and it may be temporarily stimulated by bonuses, fixation of prices and other artificial aids. But the only way to secure a genuine and permanent increase in the output from the land is to improve the farming methods of the country by the application of scientific methods of production. In other words, the problem of agricultural development resolves itself finally into the problem of agricultural education and research.

We need trained investigators to establish the principles underlying the successful cultivation of crops and the feeding and management of live stock, and the principles underlying the control of diseases of crops and live stock. We need trained specialists in agriculture to foster the agricultural and live stock industries of the State. We need trained and tactful extension workers whose efforts will be continuously directed to the improvement of practices in local communities by getting into personal touch with those whose farms have hitherto given but mediocre yields.

It may be said that sufficient has already been done in the field of research, and that it might be advisable to halt for a while to apply the knowledge already won. But there is not the slightest danger that we can be too well informed on matters essential to human progress and happiness. Rather the danger is in the opposite direction—the conceit of ignorance—that would proceed in the dark as new problems arise almost day by day. Research work has shown how to lower production costs, maintain soil resources, prevent losses from disease in crops and live stock, enhance the quality of farm products to better serve consumers and producers, and to lighten the burdens of the farm and increase the comfort and satisfaction of rural life.

The value and need for research have been demonstrated in recent years by the willingness of governments—both Commonwealth and State—to increase their appropriations for research services, and by the readiness with which private citizens and boards representing rural industries have subsidized research.

While the scientific investigator can point with pride to many achievements of a spectacular nature, his scientific colleague in the field of extension work may not be able to make so striking an appeal, and often does not receive adequate recognition for his work. Those workers, however, who are engaged in extension work have a most important rôle to perform in the community.

The effective use of agricultural and pastoral lands lies at the very foundation of plans for the improvement in the prosperity of the country. The degree to which a country can progress towards intensive and diversified agriculture depends very largely on the extent to which the personal efficiency of the farmer may be increased, and this in its turn depends on the extent to which developments in the technical and scientific fields may be incorporated into everyday practice on the farm. In other words, the rate of progress is dependent upon application of the results of modern research to practical farming, and the extension worker is mainly responsible for this application of science to practice.

The development of the extension services of the States is therefore of great importance, and men with a good cultural background, a scientific and technical training, and with a thorough knowledge of the farmer's problems will be needed in increasing numbers if the land resources are to be fully and intelligently exploited.

Experience in other countries has shown that the advancement of agriculture is accelerated by the permanent location of a trained agricultural scientist in each local district or county, and that the personality of the extension officer is a large factor in determining his success. A knowledge of the problems of the farmers, sympathy with the people, and ability to meet them on their own ground and convey practical instruction in a convincing manner are essential for success.

Important as the discoveries made in agriculture have been, there is always a serious time lag in putting them into practice. Tull, the founder of the horse-hoeing husbandry, died a broken man. Mendel's paper setting out his discoveries lay forgotten even by scientists until unearthed by De Vries, Correns and Tschermak in 1900, i.e. 34 years' delay. It took nearly a quarter of a century of intensive propaganda to bring about the widespread use of soluble phosphates in the Australian wheat belt.

Rural people are generally unreceptive to new discoveries, because they do not really understand the reasons underlying the discovery, and they are naturally self-reliant and more or less isolated. The comparative isolation of the men on the land places them in a less favourable position to secure the essential technical information than the population in the city, which has available to it the various forms of education appropriate to its needs.

The immediate objective of the extension worker is to bring about a change in practice, for the better, but its ultimate aim should be the broadening of the vision of the rural worker. In other words, the end to be sought is not only a more efficient and profitable agriculture, but a wholesome rural life and an intelligent and progressive rural people.

Extension work therefore requires a form of publicity which is designed to overcome the unreceptivity and innate conservatism of the rural people, and it is likely to be successful only when it has something of real value to teach, when it is soundly based, and when it is conducted by those who not only understand both practical farming and farmers, but are also imbued with the ideal of service to the rural community.

POPULATION ABSORPTION CAPACITY OF AUSTRALIA IN RELATION TO NATURAL RESOURCES.

I have already touched on the problem of migration and referred to the necessity of following a policy of infiltration of migrants, rather than settlement *en masse*, if and when conditions are again favourable for the resumption of migration.

The problem of providing outlets for the surplus populations of Europe and Asia has received considerable attention lately between countries classified as the " haves " and the " have nots ". There is a common belief abroad that Australia is a continent with vast empty spaces suited for agricultural and pastoral settlement, and that she is capable of carrying an exceedingly greater population than is carried at present. This belief is fostered by the publication of fantastic estimates of Australia's population absorptive capacity by so-called reputable authorities, whose estimates range from 100 to 200 millions. In December, 1935, Professor Carr Saunders, of Liverpool University, in " Headway " (the organ of the League of Nations Union), made the statement that " apart from the present world depression, America and Australia are capable of absorbing an annual average of well over a million migrants ".

He does not state what proportion of this million could be absorbed by each continent, but those reading his articles might be justified in assuming that the proportion for Australia was considerable. It is high time that Australia did something to educate world opinion as to the facts, in order to remove any possible misunderstanding regarding the absurdities of some of the population estimates, and the gross inadequacy of the data on which they are based.

There are several causes for misconception regarding Australia's capacity for population. The sparseness of the existing population in comparison with Europe and Asia is of course very striking. Our public men are to some extent responsible for the misconception by their glib habit of referring to the potentialities of our vast empty spaces for migration and settlement. Then again, comparisons are frequently made between the United States and Australia, which are similar in size, but vastly different in population, but it would be utterly wrong to assume that these two countries are really comparable in natural resources. Maps have been published showing many of the European countries superimposed on the map of Australia. The natural inference of outsiders is that Australia could carry a population comparable with those indicated on the maps. Critical investigation may show that the population capacity of Australia cannot be measured with any degree of accuracy.

There are, of course, two main directions in which additional population might be absorbed, e.g. in secondary industries and in primary industries. A valid estimate of population based on the development of secondary industries is probably hopeless, for Australia could produce vast quantities of iron and steel goods, coal, cellulose fabrics, etc., etc. Our capacity to do this would be limited only by the extent of our iron ore deposits, forest resources and black and brown coal deposits, etc., but the limit imposed on us would be not the capacity to produce, but in our capacity to consume within our own borders and sell outside them.

The case is different for the primary industries, for there is a natural limit to production, imposed by the annual productivity of the soil. It should be possible to make a survey of the land resources and to form a reasonable estimate, based on the quality of the soil and the amount and incidence of the rainfall, as to what the land would produce when developed and put to its highest and most intensive use. If such a survey or classification of land resources were available, it should be possible to demarcate the areas based on quality of soil, topography, rainfall and accessibility to markets, suited to the various forms of production, ranging from the lightest carrying pastoral country at the one extreme to the most intensive form of horticulture or gardening on the other.

Having arrived at an approximate idea of the potential maximum productivity founded on basic considerations of quality of soil and climate, it should be possible to estimate the approximate number of holdings or economic units into which the available land could be divided, based on the maintenance

of present standards of living. In any well balanced community there is generally a more or less fixed ratio between the number of agricultural holdings and the numbers of total population, so that, assuming these ratios were approximately maintained in the future, a basis for calculating population capacity of the country might be obtained. In any case, it would provide a sounder basis for calculation than those in which existing estimates were used, and would probably show that the prevailing ideas regarding population capacity of Australia are grossly exaggerated.

The South Australian Branch of the Institute, at its last meeting, had a preliminary symposium of agriculturists, economists and statisticians on the problem of the population capacity of South Australia, and the broad conclusion was reached that in regions of less than 15 inches of rain, which occupied nearly 92% of the State, there was little likelihood of any substantial expansion in the rural population, and that the so-called empty spaces of the map were almost as fully occupied as they were ever likely to be. In the better rainfall areas of the State it was considered that there was room for a substantial increase in rural population, and that if all land in the State were put to its highest and most intensive use, it was possible that the population might ultimately be increased to two and a half times its present total, though even this estimate appeared to be somewhat optimistic.

It was felt that the various Branches of the Institute might perform a useful service to Australia by attempting, with the aid of its own members and with the collaboration of economists and geographers, to survey the agricultural resources of their State and assess the probable future capacity of the various classes of lands when put to their highest use. A large amount of information on the quality of land in settled districts is already available in the Lands Departments, taxation offices and banks, and if this could be collated by a group of research workers, it might prove of considerable value in assessing the future productivity of such lands.

It is probable that the combined results of such a study would show : (1) that so-called vast empty spaces of the continent are not undeveloped, as is assumed by outsiders, but that there are manifest signs of over-development, reflected in the extensive soil erosion in the semi-arid pastoral country and in the marginal wheat lands ; (2) that the closer settlement policies of the past have been responsible for extension of the margin of cultivation beyond the area of profitable farming ; (3) that any substantial increase in the absorptive capacity of Australia, so far as its primary industries are concerned, is dependent almost entirely on the extent to which the higher rainfall country can be developed—not by mass migration, but by infiltration of new settlers in existing settlements ; and (4) that there is no scientific justification for many of the extravagant estimates of population capacity of Australia, the publication of which has undoubtedly caused much misunderstanding abroad.

CO-OPERATION IN AGRICULTURAL SCIENCE.

There is one other matter to which I should refer before I close, and that is the need for close co-operation between all institutions interested in agricultural research.

It will readily be conceded that one inevitable consequence of the development of intensive agriculture and live stock husbandry will be an increase in the number and in the complexity of the problems which will demand solution.

It is more than probable that the funds likely to be available for problems arising from the intensification and diversification of agriculture will be inadequate for the tasks ahead unless all existing facilities, workers and institutions are used to the best possible advantage. If, therefore, the moneys appropriated for research are to be used effectively there should be the utmost co-operation between investigators in related fields of work, between the various State Departments of Agriculture, and between the Commonwealth and State institutions interested in agricultural advancement.

Not all research, of course, lends itself to co-operative investigation. Naturally, much investigation must continue to be done on an individual and personal basis, but there are many problems, and especially problems of major importance to agriculture, in which co-operative effort will be distinctly advantageous.

Given complex problems in which the participating parties have a mutual interest and responsibility, and each a share and special knowledge to contribute to the problems, then organized effort will be more comprehensive, more effective and more rapid in accomplishment than the sum of the separate individualized efforts. But such co-operation must of course be more than a form of action. Its real basis must be a desire to co-operate, with the give and take always necessary in any unselfish effort for the common good. Unless this spirit is present, a co-operative enterprise will be of doubtful value, short-lived, and possibly a cause of friction.

Now many of the modern agricultural problems are so complex and so many-sided that only by teamwork can any substantial progress be achieved. Of many examples which might be cited, the control of blowfly and of noxious weeds in pastures may be taken. Both these problems are extraordinarily complex, and of course of great economic significance to Australia.

The solution of the blowfly problem calls for intensive co-operative investigations by entomologists, bacteriologists, biochemists and veterinarians working in the closest possible collaboration on such phases as : the life histories and interrelationships of the various species of sheep-striking flies, the causes of the susceptibility of the skin and the fleece to ovipositing flies, the effect of varying environments on the fly and on the sheep, the incidence of attack in

different classes of sheep, and the possibilities of control by biological means, by trapping, use of antiseptics, and by removal of skin folds, etc.

Similarly, the problem of controlling noxious weeds in pastures will need close co-operation of the ecologist, plant physiologist, chemist, agrostologist, and possibly the soil technologist, each working on the problem from his own specialized standpoint, if the problem is to be solved in a reasonable time.

The co-operation to which I have referred above concerns the individual worker or a group of workers working possibly at a single institution.

But there are wider fields of co-operative enterprise to consider. The institutions engaged in agricultural research cannot, in their own interests or in the interests of agriculture, afford to work independently, knowing relatively little of what is being done by others, otherwise serious overlapping and waste of effort will result.

The development of new facts and their applications is usually the combined result of many efforts frequently widely distributed and marking successive steps or stages. Moreover, the value and application of the results are not necessarily restricted to the State in which the facts were first observed, and the advances which one group of investigators make in clearing up a problem may be pushed further by others in another State or territory. Thus the results obtained at any one institution may become of national importance to Australia.

The public, whom we all serve, are not interested in divorcing agricultural science and the agencies which represent them, but rather in their union by joint effort. Each institution, therefore, will gain greatly in public estimation by freely co-operating with other institutions on sound projects for the improvement of agriculture.

One gratifying feature of the past decade has been a growing spirit of co-operation between the various institutions interested in agricultural research. When the C.S.I.R. was given both the authority and the necessary funds to embark on research into the primary industries, one of its first steps was to convene a conference of all agricultural interests in Australia to define the relative spheres of the Commonwealth and the States in the field of agricultural research, and to establish machinery for consultation and co-operation. One result of that conference was that the respective fields of research by each group were fairly clearly delineated, and a Standing Committee of Agriculture was formed to bring about the closest possible collaboration and co-operation.

That Committee has proved most useful not only in promoting co-operation between the Commonwealth and the States, but also in bringing about a better understanding in agricultural research between the States themselves. This Committee has continued to function for ten years, and now forms the advisory body to the Australian Council of Agriculture, a council comprising the

Commonwealth and State Ministers interested in agricultural development. By this means, therefore, co-operation in agricultural development has been extended to the political sphere.

During the past year, a further significant step has been taken by the Commonwealth appropriating for a period of five years a sum of £30,000 per annum, for post-graduate work in the universities of Australia, in those fields of research in which the C.S.I.R. is particularly interested.

There are possibilities of co-operation on an even wider scale in the solution of problems that are of major economic importance to the various dominions of the Empire. In the scientific problems associated with the production and utilization of such a product as wool, which is of importance in the economy of Australia, South Africa, New Zealand, and to a lesser extent Britain, there would be signal benefits to each dominion if by co-operative planning of research the investigation in the various scientific aspects of the production problems—animal nutrition—animal disease—animal genetics—could be distributed among the dominions for concentrated attack by a first-class team of research workers, instead of each dominion attempting to cover the whole of each field with insufficient personnel and equipment.

Similarly, the problems associated with wool utilization might be concentrated in the United Kingdom.

The whole of the Empire and each part would give materially by co-operative planning in common broad fields of research, and by making available to each group of workers the knowledge and experience of every other group.

In one field of activity—the dissemination of information among the workers of the Empire—such co-operation has already become well established. The Imperial Agricultural Bureaux, jointly financed by the whole Empire, have proved of invaluable service to research workers, and have enabled them to keep in close touch with the most recent developments of applied research throughout the world.

Co-operative effort has received a marked stimulus during the past decade, and it is sincerely to be hoped that this spirit of co-operation will still further develop.

The Australian Institute of Agricultural Science can play a prominent part in encouraging this co-operation, and in forging and maintaining new links among all agricultural scientists and agricultural institutions in Australia.

The Numerical Relation between Agricultural and Total Populations

By

G. SEAMAN,
South Australian Audit Office.

[*The following is the address given by Mr. Seaman at the November, 1936, meeting of the South Australian Branch of the Australian Institute of Agricultural Science, when a discussion was held on "The Possible Population Carrying Capacity of South Australia".*—ED.]

The consideration of the numerical relation which exists between agricultural and total populations in its most simple aspects, is merely a matter of arithmetic. To go deeper and analyse trends, one is involved in matters of economic history and social welfare, as well as the intricacies of statistics. To go deeper still and attempt to make forecasts of the future is a most difficult and doubtful procedure. I realize it is this last in which you are most interested, but I fear it is the most incomplete portion of this paper. The calculation of the numerical relation and the analysis of past and present trends are both absolutely essential as a basis for any forecasting. I shall discuss these, and except for a few suggestions as to probable trends in the *immediate* future, shall leave the forecasting to you.

The numerical relation, I shall call the "multiplier". Before the multiplier can be calculated, one must be clear as to the definition of agriculturalist. For these purposes, in order to follow the same lines as in your previous discussions, I am taking the term agriculture as more or less synonymous with primary production, excluding, however, mining, fishing and forestry. This is indeed arbitrary. The actual "multiplier" calculated for South Australia at the last census date (1933) was 10·9. That means that for every one person engaged upon agriculture, 9·9 persons are otherwise engaged. This 9·9 includes persons engaged in secondary, transport, distributive service and other industries, and also dependents of all bread-winners (wives, children, pensioners, paupers, etc.). The absolute extent of the multiplier (10·9) has very little value or meaning in itself. I mean to say that had I told you, instead, that it was 8, or 12, or 18, you would have had a very little different picture of the composition of the South Australian population. The multiplier is little more than an index, and hence its main value is obtained through the comparison with other indices, especially with indices for South Australia at other times, and also with indices for other countries.

Now the question arises, do these multipliers follow any definite or even approximate law? Is there a functional relationship between agricultural

and total populations ? The total population is certainly not a simple function of the agricultural populations, for the multiplier varies greatly from country to country. Can it be a function of agricultural population and its productivity, or, in other words, is it a function of raw material supplies ? Malthus, early last century, believed that it was. He said that as soon as increased food supplies became available, then there appeared more mouths to eat it. " Population ", he said, " was always on the point of exceeding food supplies ". Malthus's theories are now ridiculed. But after all, he merely made the mistake of assuming that a state of affairs which existed at his time, and had existed for centuries, would continue.

We find certain trends in the twentieth century. It may be possible to find a relation existing between the multiplier and standards of living from country to country. But let us beware of making unjustified assumptions that such trends and such a relation will continue for considerable periods and under different conditions. The most we can do is to make intelligent forecasts of the *immediate future.*

To get down to actual figures. I have taken in all cases census figures, as they are evenly spaced and more reliable. In South Australia the multiplier has changed from 8·8 in 1901 to 9·4 in 1911, 10·4 in 1921, and 10·9 in 1933. In Australia, as a whole, the multiplier has been greater, but has shown the same trend, viz. 1901, 9·8 ; 1911, 10·2 ; 1921, 11·5 ; 1933, 12·1. The greater multiplier for Australia, as a whole, than for this State is, of course, due largely to the fact that South Australia has fewer secondary industries *per capita* than Australia.

The trend is definitely and consistently upward. Before one can really understand and interpret this trend upward in the multiplier, more information is necessary : we need to know what have been the trends in acreage and production. Here I have been forced to narrow down my survey and consider only agriculture proper, that is, the cropping of land, including the production of wheat, barley, oats, maize, sugar, fruits and wine.

In South Australia, the average acreages cropped in the quinquenniums centred at the census dates were (in round figures) : 2,300,000 in 1901, 2,800,000 in 1911, 3,300,000 in 1921, and 5,100,000 in 1933. This meant that the number of acres cropped per agriculturalist moved from 66 to 73 to 86 to 130 over the three intercensal periods. In Australia, as a whole, the change has been similar, but more extensive. From 1901 to 1933 the acreage cropped moved from 9 to 22½ million acres, and the acreage per agriculturalist from 32 to 70. The rapid increase in acreage per person is to some extent the result of the taking up of the less satisfactory lands, but a careful examination of the figures makes one doubt whether it could account for as much as one-third of the increase. Even in the good districts the same number of people are cropping larger areas than before, or fewer people are engaged in cropping the same area.

Increased use of machinery, more rapid transport, more scientific methods are making man's control over Nature more extensive.

During the last few years there has been another change in South Australia, and to a lesser extent in many other countries. The actual acreage cropped has been reduced by one-fifth or more by the abandoning of sub-marginal lands. This will, undoubtedly, temporarily reduce the acreage per agriculturalist, but will not counteract the general tendency for it to increase. Hence, if acreages do not again increase, we may expect an absolute decrease in the number of agriculturalists. This is, in fact, already occurring.

But while acreage cropped per agriculturalist has been increasing, what has been happening to production ? Here I have been forced to construct indices of volume of production. To take value of production would, of course, be quite unsatisfactory for the purposes of comparison of physical productivity from time to time. I find that in South Australia the volume of agricultural production (narrowly defined) rose from 1,000 in 1901 to 2,400 in 1911, 2,900 in 1921, and 4,200 in 1933. The productivity per acre rose from 1,000 in 1901 to 2,000 in 1911, remained at 2,000 in 1921, and fell to 1,850 in 1933. The rapid growth in productivity per acre between 1901 and 1911 was due almost entirely to the rapid introduction of the use of superphosphate for cereal crops, but since that time the extension to worse lands has counteracted the tendencies to greater productivity per acre.

The productivity per agriculturalist in South Australia shows very rapid rises from 1,000 in 1901 to 2,200 in 1911, 2,600 in 1921, and 3,600 in 1933. Comparable figures for Australia as a whole show a similar trend.

Then the fairly rapid rise of the multiplier in South Australia and Australia during the twentieth century has been the result of (1) the growth of agricultural population at a rate slower than the growth of total population ; (2) whereas there has been a trend to increased acreage per person, any increase at all in agricultural population has been rendered possible only by the rapid extension of settled areas ; (3) the increasing productivity per person has doubtless been a powerful factor in extension of acreage per person.

THE POSITION IN OTHER COUNTRIES.

Let us now consider the state of affairs in other countries. The figures available are of a diverse, and, in some cases, of a doubtful nature. I have selected a number of the more reliable and representative cases. However, the multipliers will in no cases be strictly comparable with the South Australian multiplier. The industrial structures of nations differ widely. South Australia, for instance, exports 50% of her primary produce, and very little else, while the United Kingdom imports most of her food supply and raw material requirements. To take into account the state of each country's international trade will allow us to obtain rough comparisons of multipliers.

The South Australian multiplier for 1933 was 10·9, and the Australian 12·1. Since this State has a greater *per capita* export of primary products, there is probably no considerable difference in productivity per agriculturalist, despite wide variations in productivity per acre.

In 1921 the multiplier for France was 4·3, and by 1926 it had risen to 4·9. For Italy, in 1921 it was 3·8, and in 1931, 5·1. Both Italy and France are nearly self-sufficient in agricultural production, and their productivity per agriculturalist would seem to be much the same in those two countries, but very much below that of Australia, which, although it has but one person in 12 engaged in agriculture (as compared with one in five in Italy), has considerable surplus for export. Germany in 1925 had a multiplier of 6·4, and in 1933 this had risen to 7·0. Although Germany imports considerable quantities of certain raw materials, it would seem that her agriculturalists are slightly more productive than those of France and Italy. In Canada, in 1921 the multiplier was 7·9, and in 1931 it was 8·5. The export *per capita* of primary produce is little, if at all, greater than for Australia, and hence our productivity is clearly greater.

At the census dates 1910, 1920 and 1930, the Unites States of America multipliers were 7·3, 9·7 and 11·4. The *per capita* export of primary produce is not as great as Australia's, and hence the agricultural productivity falls slightly short of the Australian. New Zealand shows multipliers of 8·7 in 1911, 8·8 in 1921, and 10·0 in 1926. The United Kingdom, however, in 1911 had a multiplier of 28·2, in 1921, 32·6, and in 1931, 33·3. The enormous import *per capita* of primary produce (probably over three-quarters of domestic needs) would make it appear that the productivity of the British agriculturalist is not as great as that of the Australian, American, Canadian or New Zealand.

In Italy, France, Germany, the United Kingdom, United States of America, and even New Zealand, there have actually been decreases in total agricultural populations between recent censuses. It is, however, noteworthy that in every case there has been an increase in agricultural production, and in acreage, meaning that the production and acreage per person engaged have risen considerably. The same trends are apparent in all these countries as in Australia, viz.: (1) rapid and sustained increase in multiplier; (2) either slow increase in agricultural population coupled with rapid extension of settled areas, or actual decrease in agriculturalists coupled with a slower extension of acreage; (3) increase in acreage per person; (4) increase in productivity per person, and in many cases in productivity per acre.

It is noteworthy that decreases in agricultural population have occurred in certain countries despite energetic attempts to foster rural development, and that increases in acreage per person have occurred despite attempts to foster closer settlement. South Australia has for many years given encouragement to land settlement and extension of rural industries. Yet despite this,

since 1901 at least 70% of the male natural increase of the rural population has sought other than rural occupations.

Are the trends likely to continue at the same rate, or greater rate, or change altogether? To obtain an answer we must look at the factors which might influence those trends.

FACTORS INFLUENCING TRENDS.

Standards of living are rising the world over. After our primary needs of food, clothing and shelter are reasonably satisfied, we aim to satisfy other wants. As our incomes increase beyond a certain level, we do not wish to eat more bread and more meat, or wear more clothes, or even live in much bigger houses. We want more amusements, more education, more of those things which make life more interesting and more comfortable. Naturally, then, the greater part of any increased power which accrues to a community will be devoted to these things, and the production of primary products will take a progressively smaller part in the total community effort. This would seem to indicate a rising multiplier over the world in general, although it may not necessarily mean a greater multiplier for any one specific nation. It is perhaps conceivable, though from present indications extremely doubtful, that a few countries may become the suppliers of primary products to the rest of the world.

There is one factor which may give a special impetus to a temporary increase in the proportion of primary to total production. According to various estimates 60%, 80%, or even more of the inhabitants of the earth are inadequately or incorrectly nourished. More scientific feeding would mean probably less bread and less beef, but more milk, butter, eggs, lamb, fresh fruit and vegetables. It is worthy of note that in recent years there has been a rapidly growing overseas market for most of these products.

In Australia at present there is a justifiable feeling that we should concentrate less on the extension of our rural industries, but more upon the secondary and tertiary industries. It is realized in many quarters that the much-boosted settlement schemes have been disproportionately costly, while the much maligned protective policy for the encouragement of local secondary industries has proved a success. It must be admitted that were Australia, in 1929, entirely a rural community, it could not have averted bankruptcy and much greater poverty than it actually did experience. The trend in markets overseas is not encouraging to further extension in primary production here. All of our best markets are contracting, because of attempts to foster local food production in those countries. Furthermore, the populations of those countries have even now practically ceased to increase, and in a generation or so will probably decrease.

The pre-depression trends toward extension of land settlement have ceased, and are unlikely to commence again at anything like the old rate. Something

may be done with closer settlement. However, it is likely to be our experience, as it has been in other countries, that such closer settlement as may be achieved will be more than counterbalanced by the trend toward greater acreage per agriculturalist.

It is probable that the trend toward greater productivity per acre on the already settled lands will continue. This will mean that, unless markets expand, an actual decrease in acreage may occur. For whatever may have occurred in Malthus's time, in this twentieth century increased food supplies are not automatically followed by increases in population.

It has been said that to increase the Australian population considerably by immigration will give a stimulus to rural production by substituting a sure home market for a doubtful export market. This is open to doubt. Our immigrants will presumably come, if at all, from England and Western Europe. The added demand in Australia will be counteracted to a considerable extent by a decreased demand in those countries. Even if this were not so, migration, which did not at least double our present population, would not relieve us of the necessity of disposing of large quantities of primary produce abroad.

Practically all these considerations point toward a continuance of the rise in the multiplier in Australia. But as I pointed out before, one must be very careful when forecasting. New and unforeseen factors may enter in, and trends in economic affairs have an uncomfortable habit of disappearing just when everyone has come to look upon them as permanent.

What the South Australian multiplier would be, should all our land be settled to the scientifically determined greatest possible extent, it is quite impossible to say. It is only possible to make forecasts upon observed trends a short period ahead, assuming conditions do not substantially alter. An agricultural population such as conceived in your estimates is not a practical possibility in the near future. In order to absorb the increased produce, either overseas or local markets must undergo revolutions. Theoretically, the multiplier may be anywhere between 5 and 30. It would be 5 if for every one person engaged in agriculture one were engaged in commerce, distribution and necessary manufacturing, and each had one and a half dependents, as at present, and by some miracle practically all the produce were sold overseas. It would be in the region of 30 if agricultural productivity remained unchanged, and the State, by some other miracle, obtained a population sufficiently large to consume the total production. Further than that I fear I cannot go.

The New Era in Breeding Wheats Resistant to Stem Rust

By

S. L. Macindoe, B.Sc.Agr.,
Plant Breeder, New South Wales Department of Agriculture.

Plant pathologists working under strictly controlled conditions have made valuable contributions to our knowledge of the nature of disease, but there has simultaneously been a move on the part of plant breeders to discard " over-refinement " in much of their technique, and to rely to a greater and greater extent on breeding under conditions approximating as nearly as possible those which are normal to the locality in which the crop is to be grown. That the results have more than justified this course of action may be evident from the following very brief summary of the efforts so far made to breed stem rust-resistant wheats.

EARLY WORKERS.

Farrer[2] first evolved and applied the idea of breeding stem rust-resistant wheats by combining the resistance of one parent with the desirable agronomic characters of another. He worked under field conditions, and with the simplest technique achieved considerable success. He demonstrated the success of his method in the production of wheats such as Florence and Warren. Farrer never claimed that such wheats were highly resistant to rust, for he only hoped that they would be " reduced from twenty bushels by not more than three or four bushels, instead of *to* four or five bushels of pinched and worthless seed ".

No highly resistant wheats were known to exist until the discovery of the durum wheat Iumillo, and Farrer, shortly before his death in 1906, had actually arranged to introduce this wheat. Farrer worked under field conditions, but unfortunately his plots were in a district and on a soil type not conducive to heavy rust epidemics. Nevertheless, his observations were sufficiently comprehensive for him to conclude that the relative rust reactions of the varieties with which he was working were constant. These varieties, under field conditions, still show the same degree of resistance or susceptibility to rust as Farrer's records show them to have exhibited forty years ago. Even a variety such as Bobs, which Farrer released as being relatively rust-resistant, he found to be heavily infected under more severe epidemic conditions—a change readily accounted for by environmental influences.

Biffen,[1] in England, also working under field conditions, subsequently showed that the Mendelian laws of inheritance were applicable to the breeding of rust-resistant wheats, the resistance of which appears to have been retained over the past thirty years.

In 1917, Waldron and Clark,[13] working in the United States of America, discovered the wheat Kota as a " stranger " plant in a sample of durum wheat received from Russia. As it was under field conditions considerably more resistant to stem rust than Marquis, these two varieties were crossed and the variety Ceres evolved. This wheat, in addition to being high yielding, has for a number of years carried a very satisfactory degree of resistance to stem rust in all but the most severe stem rust epidemics. For ten years Ceres has been grown commercially in the United States, and it is the leading variety over large areas. It was not until the 1935 epidemic that the abnormally hot and humid conditions caused it to suffer from rust injury, but it was previously known not to possess the near-immunity to stem rust of some other varieties now available.

A HIGHER STANDARD OF RUST RESISTANCE.

As extremely high resistance to stem rust was unknown amongst the bread wheats, attention was turned to varieties of durum and emmer wheats as a source of such resistance. Hayes, *et al.*[5] in 1914, crossed the resistant durum variety Iumillo with Marquis, and eventually released the bread wheat variety Marquillo, which possessed much of the high resistance of Iumillo, but also, unfortunately, the high carotin content of that variety, which resulted in a flour of undesirable colour. This cross is, however, of special interest, as a sister line to Marquillo was later crossed with a Kanred-Marquis hybrid, giving rise to a number of " double cross " lines, the best of which has recently been distributed and enthusiastically received under the name of Thatcher. This variety is now being grown on thousands of acres in the spring wheat belt of the United States and Canada, and in 1935, when Marquis practically failed through stem rust and Ceres produced only half a crop, Thatcher yielded heavy crops.

In Canada, the extremely high field resistance of the durum variety Pentad has also been transferred to bread wheats of good type by breeding under rust nursery conditions in the field.

Yaroslav Emmer, which has been known to be practically immune to stem rust for fifty years, was crossed with Marquis by McFadden,[7] in 1916, and from this cross, grown in bulk for several generations, Hope and H.44 were eventually selected for their near-immunity to stem rust in the field. Unfortunately, the resistance of these two varieties appears to be coupled with the lack of drought resistance, but more recently there have been indications that in crosses with some parents it is possible for this association of rust resistance and susceptibility to drought to be broken down.

Another group of most valuable stem rust-resistant bread wheats has been evolved by Burton in Kenya Colony. Apparently the origin of this resistance is not known, but in view of the grain characters of the most resistant line received by the writer, it is not unlikely that it is of durum origin. These

wheats were first received at Glen Innes in 1930, and their immunity under a most severe rust epidemic immediately attracted attention. As they have evidently failed to receive recognition outside their country of origin, the writer[6] drew attention to their high resistance, a character which has been retained in many tests over the past six years. Especially in the severe midsummer plantings, this resistance has been even more pronounced than that of Hope, Marquillo and the Pentad-Marquis hybrids. In addition, it has been found to be more easily recovered in back crosses and multiple crosses than the resistance of any other parents. Samples of these wheats sent to Peru have been highly resistant under conditions where even the resistance of the American parents has broken down. Recent reports from Canada have also indicated the comprehensive resistance which it was anticipated that these lines would show.

BREEDING UNDER FIELD CONDITIONS.

It is very significant to find that, with the partial exception of Hayes, who used glasshouse seedling tests to augment field selection, all the workers responsible for the evolution of these epoch-making rust-resistant parents have achieved success by working under field conditions. One or two other workers have taken the desirable precaution of introducing physiologic forms of known identity into their field rust nurseries, but some have worked successfully without even a knowledge of such forms present.

This fact is, however, not so surprising when it is realized that physiologic forms, as they have been determined in the past, have been established on the basis of seedling reaction in the glasshouse. Melchers and Parker,[8] as early as 1922, showed, however, that varieties or hybrids which might be susceptible to certain forms in the seedling stage in the glasshouse, might be highly resistant after heading in the field. Goulden, *et al.*[4] confirmed this observation and stated emphatically the desirability of entering on a new phase of breeding for rust resistance under field conditions.

It is true, of course, that in certain cases seedling resistance may be correlated with resistance in the post-heading stages. Neatby[9] has shown that this correlation depends primarily on the resistant parents used and the rust forms present. It will, however, be admitted that the reaction of a variety under field conditions must be acceptable as the final test of its resistance or susceptibility, and provided breeding work can be undertaken in localities where successful field rust nurseries can be established, there appears to be little necessity for relying on seedling inoculation in the glasshouse which, at least in some cases, can only complicate rather than simplify the breeding programme.

NATURE OF RESISTANCE.

It has been commonly accepted that there are various types of resistance such as morphologic, physiologic and functional resistance, which apparently

account for differences in the types of rust reaction exhibited by varieties in the field. Newton and Brown[10] have shown that the young tissues of many varieties which are susceptible to certain physiologic forms of rust, become highly resistant to the same forms as they grow older, and are therefore more fully differentiated. They considered that this resistance was not morphologic, but was due to protoplasmic changes in the cells which rendered them highly resistant. Popp[11] also showed that various varieties become resistant to stem rust at different stages of their development, and he concluded " that in varieties such as H.44–24, Hope and Acme, the rôle which the sclerenchymatous tissue plays in conferring resistance upon a plant is only of minor importance in comparison with the physiologic resistance which the various parts develop with advance in age ".

In addition to the numerous other factors influencing the host-parasite relationship, it is obvious that the stage of maturity of the plant is a factor of paramount importance. It is therefore logical that, as far as possible, resistance should be determined at that stage of the plant's growth at which it is most vitally exposed to attack by stem rust, that is, at the after-heading stage.

THE SIGNIFICANCE OF PHYSIOLOGIC FORMS.

While it is true that those who discovered and stressed the importance of the presence of physiologic forms of pathogenic fungi opened up an important field of biological investigation, it is probable that unwittingly they retarded progress for a decade or two in the production of stem rust-resistant varieties. The multiplicity of physiologic forms and the constant anxiety of the possibility of new forms appearing caused many agronomists to vacate the field of breeding rust-resistant varieties of wheat. Pathologists themselves found that the problem of breeding could be simplified by breeding for resistance to groups of physiologic forms, but when Goulden[3] showed that the " mature plant resistance exhibited by certain rust-resistant varieties appeared to apply equally to all the known forms of rust ", and that " the inheritance of mature plant resistance is entirely independent of seedling resistance, and is very simple in nature ", plant breeders again commenced to utilize this type of resistance as they would that of any simple morphological character such as " beard " or " colour of grain ".

It is, of course, desirable that breeders should be intimately acquainted with the nature and possible menace of rust forms. A physiologic form is an arbitrary division of the rust fungus, which is heterozygous in nature and in many respects comparable to a grass " strain " ; each has, in effect, a vegetative as well as sexual means of reproduction. Just as each " strain " has its range of climatic and soil adaptability, so a physiologic form is restricted in its adaptability to its environment composed of the host, the soil and the climate.

Because of the heterozygous nature of both, segregation and recombination during the sexual reproduction of both types of plants may lead to some

modification of their adaptability, but in both cases there appears to be a more or less well-defined limit beyond which selection cannot be pushed within the species. In the case of rusts, therefore, progress can at least be made on the tentative assumption that a group of varieties which have been nearly immune to rusts for many years under certain environmental conditions are likely to retain their resistance, at least under those conditions pertaining in the particular locality.

Those who continue to make use of seedling resistance point to certain advantages of this system :

(*a*) In almost all cases, plants resistant in the seedling stage are also resistant at maturity. On the other hand, it must be admitted that to continue to breed for seedling resistance to certain forms to which the plant is resistant at heading is unnecessarily adding to the task of the breeder, who is always fighting against time. Moreover, by making use of a type of resistance which appears to apply equally well to all known physiologic forms, it appears more reasonable to expect that this resistance also will apply to any new forms which may arise. Indeed, examples are not wanting in which seedling resistance has actually broken down with the advent of a new physiologic form in the field, while mature plant resistance appears to remain more or less constant in any particular locality, and in this respect it appears to be a more comprehensive type of resistance.

(*b*) Under glasshouse conditions the environment can be, to a large extent, standardized. It must be admitted, however, that conditions can never be absolutely standardized, and that certainly in the past much confusion has existed in the identification of physiologic forms through failure to allow for differences in temperature. Standardization may also be a danger, since climatic conditions themselves show such wide fluctuation. Furthermore, to standardize to conditions which are much more severe than those likely to be encountered in the locality may be wasteful of effort. The establishment of field rust nurseries over a range of climatic conditions has proved to be very satisfactory, and has indicated the relative constancy of varietal reaction to rust under field conditions.

(*c*) Rust forms which are absent in the field may be used for inoculations in the glasshouse. It is known, however, that physiologic forms are themselves restricted in their adaptability, so that to continue to breed for resistance to forms which may not be able to survive under the field conditions of the district is taking precautions which are scarcely warranted.

(*d*) The mature plant resistance of Hope and some of the durum derivatives has apparently broken down under the climatic conditions of Kenya Colony and Peru. Waterhouse[14] has shown, however, that seedling resistance may be at least as susceptible to climatic influences. Indeed, the moderate physiologic resistance of a wheat variety like Ford planted out of season in the field is

apparently converted to complete susceptibility, although the variety is recognized as having a very useful resistance even under moderately severe epidemic conditions. When the influences of climate and soil both on parasite and host are considered, it is not surprising that combinations do occur which are capable of radically altering the host-parasite relationship. The long record over at least most of the globe of the high resistance possessed by certain varieties would give encouragement to the belief that their resistance is not likely to be materially changed by the environmental fluctuations encountered in those localities where they are being used as resistant parents. Stakman[12] has suggested that the more frequent pustules found even on Hope in 1935 may have been due to the abnormally reduced light intensity experienced in that year. While, therefore, it must be admitted that resistance as we know it is capable of some modification by environment, this points rather to the necessity for regarding the breeding of disease-resistant plants as a local problem.

While the occurrence of physiologic forms cannot be overlooked, it should at least be recognized by pathologists that in view of the differences which exist between seedling and after-heading reactions of many important parents, physiologic form determinations, to be of any real benefit towards elucidating the problem of the plant breeder, should be established at that stage in which plants become exposed to the vital stage of infection in the field, that is, at the after-heading stage.

RESISTANCE OF THE KENYA WHEATS.

As yet little is known of the type of resistance possessed by the Kenya wheats, although Waterhouse, in unpublished data, has indicated that some of them have seedling resistance to the prevalent Australian rust forms. While some lines appear to show at the after-heading stage the resistant pustules typical of varieties carrying seedling physiologic resistance, the resistance of Kenya C.6040, the most valuable line, appears to amount to immunity under Australian conditions and in summer plantings. Where the relatively resistant Ford has failed to head through rust infection, Kenya C.6040 and its hybrids have shown not even the trace of a resistant pustule. Although, therefore, it would be premature to state that this line possessed, in addition, a mature plant resistance similar to that of Hope, the fact that it is resistant under equatorial conditions, where even Hope, Marquillo and the Pentad × Marquis lines have been susceptible, would indicate that it can with confidence be used as at least a near-immune parent in breeding rust-resistant wheats under field conditions.

The desirability of these Kenya wheats in general agronomic characters, their satisfactory yield, and the absence of any apparent tendency for their type of rust resistance to be associated with undesirable characters, such as

drought susceptibility or straw weakness, are additional factors recommending these wheats to the use of the Australian wheat breeder.

APPROACHING THE DESIDERATUM.

While none of the first crosses between Australian wheats and the resistant American parents are likely to enter general cultivation, numerous back-crossed lines with stronger straw and high resistance are undergoing further observation.

There appears to be little doubt, however, that more rapid results will be achieved by the use of the Kenya resistant parents. Although these have only been used in crosses since 1931, a number of advanced generation hybrids are now available as the result of the raising of two and three generations in the one year. The most promising lines are from a Kenya × Florence × Dundee cross, which is already being tested on a field scale. Subsequent crosses of these with Pusa 4 and related lines give promise of combining very high baking quality with the stem rust-resistance, straw strength, and good yield of these lines.

REFERENCES.

(1) Biffen, R. H. Jour. Agr. Sc. 2 : 109–128, 1907–8.
(2) Farrer, W. Agr. Gaz. N.S.W. 9 : 131–167, 239–250, 1898.
(3) Goulden, C. H. Scientific Agr. 10 : 258–267, 1929.
(4) Goulden, C. H., Newton, M., and Brown, A. M. Scientific Agr. 11 : 9–25, 1930.
(5) Hayes, H. K., Parker, J. H., and Kurtzweil, C. Jour. Agr. Res. 19 : 523–542, 1920.
(6) Macindoe, S. L. Agr. Gaz. N.S.W. 42 : 475–484, 1931.
(7) McFadden, E. S. Jour. Amer. Soc. Agron. 22 : 1020–1034, 1930.
(8) Melchers, L. E., and Parker, J. H. U.S. Dept. Agr. Bull. 1046, 1922.
(9) Neatby, K. W. Scientific Agr. 13 : 625–635, 1933.
(10) Newton, M., and Brown, A. M. Canadian Jour. of Research 11 : 564–581, 1934.
(11) Popp, W. Proceedings of the World's Grain Exhibition and Conference 2 : 238–243, 1933.
(12) Stakman, E. C. Stem Rust in 1935. Minnesota Mimeographed Sheet, 1935.
(13) Waldron, L. R., and Clark, J. A. Jour. Amer. Soc. Agron. 11 : 187, 1919.
(14) Waterhouse, W. L. Proc. Linn. Soc. N.S.W. 54 : 615–680, 1929.

Recent Progress in Pasture Research in Great Britain

By

E. F. Fricke, M.Sc.Ag.,
Department of Agriculture, Tasmania.

An increasing area of the natural pastures of Australia is being sown down with exotic species, the majority of which have been in general use in Great Britain for many years. The performance of these species, and their recently produced strains, in Great Britain is a matter of considerable interest to Australian agrostologists, particularly those in the temperate and well-watered regions. Of more general interest, however, is a survey of the methods being used in the study of pasture problems, and of some results of outstanding importance.

The devising of methods of research on the improvement of pastures is usually recognized as being more complex than that for similar work on arable crops. In both cases the objective is ultimately to determine what combination of the alterable factors will give the most economic production in a particular region. In pasture research the greater number of varying factors governing production complicates the investigation. An illustration can be given in the apparently simple problem of determining the effect of a manurial dressing on a pasture. In the case of an annual crop it is usually necessary to measure only such single effects as quantity and quality of grain or other product. In a pasture we have in the first place usually more than one species, and secondly their life is generally more than one season. Moreover, neither of these complexes can be readily separated for study, as they interact with one another continually.

The application of a manure to a pasture mixture will generally alter the balance of species composing it. This alteration will affect the next season's growth. The effect must therefore be studied for two or more seasons. The pasture meanwhile is probably undergoing a normal process of change in composition, part of which may be due to seasonal conditions. This is well shown by a study of the classical pasture experiments at Rothamsted. The application of the same treatment to pasture hay plots for many years has tended to form a stable plant association, but large differences in composition are found in some years. It has been shown by Brenchley[1] that these differences are due to previous seasonal conditions. A pasture experiment should therefore continue for several years, with, in the case of sown pasture, sowings in successive years.

The need for estimation of error, and the value of factorial design, is not as well recognized for pasture experiments as it is for crop work, while the

convenient device of confounding treatments does not appear to have been used so far in pasture experiments. It is probable that the use of the latter will be restricted owing to the absence of preliminary information on the interactions involved. The example of a non-replicated manurial experiment described by Yates[2] would probably be applicable, but if varietal differences are introduced as in the example given by Cornish,[3] the interactions may be large. The reduction in the number of plots made possible by this type of experiment should be of great assistance in pasture work where the cost per plot is high, and where actual yields are often not important, the significance of the effect and the trend of the response being all that is required.

It has been assumed in the above that yield data are to be obtained in the form of a single cut of hay, this being the simplest method and analogous to that used in cereal experiments. A more usual requirement is a measure of the production throughout the growing season. This is frequently done by replacing the single cut by a series of cuts at suitable intervals. If the pasture is to be treated in that manner in practice, as in the case of feeding cut herbage to stock or where grass is being produced for artificial drying, this method is valid. If the pasture is for grazing purposes, the effect of cutting on the composition of the sward will usually be so different from grazing as to render the results of little value.

QUADRAT AND SAMPLING METHODS.

The most important effect of the presence of grazing animals on the pasture is probably that of the deposit of their excreta. Woodman at Cambridge topdresses cut pasture plots with farmyard dung. The grazing animal, however, affects the pasture in two other important ways : by selective grazing and by trampling. This is provided for in the enclosed quadrat method, which is used in several States of Australia, and by the sampling method which is favoured by Davies at Aberystwyth. In the former, an enclosed sample of the pasture is left for cutting after grazing, in the latter a sample is taken from the pasture before grazing. The enclosed quadrat method seems the more generally suitable method under Australian conditions. Firstly, it allows a closer approximation to our more extensive methods of grazing, and, secondly, our better drying conditions allow the use of the frames as supports for air-drying the cut herbage in the field.

Under intensive grazing management and in wetter districts, the sampling method is preferable. After an exhaustive statistical study, Davies[4] has adopted the following method : A field sample of about ten pounds fresh weight is cut before grazing. From this two samples are drawn, the first of about two pounds for dry weight determination, this quantity being found to dry indoors in a fortnight, and the second of one pound for botanical analysis. Instead of separating the latter into species and weighing, an eye estimation

on ten sub-samples is found to be sufficiently accurate, and to take very much less time.

Where analyses are made on the herbage *in situ*, mesh estimations at the rate of ten per plot have been found necessary. For critical work with small species, and in wet weather, turves are lifted and examined in the laboratory. With small plots required for further sampling, these should be replaced. Plots should be replicated at least five times.

It is desirable to emphasize the importance of fencing off each plot when large differences in growth or composition of the herbage are expected. Where these occur, as in a manurial experiment, the effect may be soon masked if stock are allowed to travel at will over the whole area. In the first place, dung tends to be spread evenly over all plots instead of being returned to the plot from which the original herbage was removed. This evens up the fertility and spreads seed. Further, those plots which produce the earliest herbage will be grazed hardest at first, and consequently weakened. Where large differences in the quality of the herbage occur, as in a species or mixture comparison, the more palatable will be eaten down much more severely than the remainder.

The tendency of differences between unfenced plots to disappear is well shown by an experiment at Jealott's Hill. Martin Jones laid down a series of plots with pure species of various grasses and clovers. After four years of uniform grazing and manuring over the whole area, it is now impossible to detect the original plot divisions.

Whether closed quadrats or sampling cuts are used, the yields are in the form of weight of nutrients, the function of the stock being merely to subject the pasture to grazing, treading and dunging. The transferring of food units into units of animal produce presents certain difficulties, the chief of which is that of estimating the energy output of stock during their movement in the field. Calorimetric studies at Cambridge have shown that the act of getting up and lying down causes large transformation of energy. The trend is, therefore, to measure the value of a pasture directly in units of animal product.

The most satisfactory method, used by Jones at Jealott's Hill, is to rotate a group of stock within each treatment. Changing stock from one treatment to another introduces two possible errors : the carrying over of fertility in the dung, and the tendency of stock to eat most where they like it best. The results consist of weights of the animal product, and the number of stock days, both of which can be expressed in market rates of value.

The cost of fencing and the supervision required with the large number of plots involved are likely to make the cost of such an experiment somewhat high. Practical difficulties are to get the plots evenly grazed and to prevent stock from scouring, when they are repeatedly turned on to fresh succulent pasture without access to older growth. At Aberystwyth, this has lead to the use of tethered sheep. The following method is used by Iorwerth Jones.[6]

The width of a plot is made four times the length of the tethering chain, the length of the plot depending upon the productivity of the pasture. The tether is moved along one-half of the plot and back the other half, at a rate depending on the rapidity of growth. Two sheep are used on each tether, to prevent rushing about. One or more pairs may be added to a plot as required. Live weights are taken at suitable intervals, and sheep days are recorded. Sample cuts of the available and uneaten herbage are taken in the crescent ahead of and after each movement of the tether. This method has a few disadvantages. Even when the tethers are moved twice a day and only a yard at a time, the sheep tend to graze at the end of the chain. The result is a somewhat wavy appearance to the pasture. The chain also is damaging to a young pasture. Jones is now experimenting with a movable frame on wheels to enclose the sheep. It results in more even grazing, and sheep can be added singly. A further advantage for Australian conditions would be that a supply of water and shelter from the sun could be attached to the frame.

EFFECT OF TIME OF GRAZING.

The most outstanding work on intensively grazed pastures done recently is that on the effect of time of grazing on the composition of the sward. The original plots laid out by Martin Jones at Jealott's Hill were seen just after the completion of the work. Starting with a uniform mixed pasture of ryegrass, cocksfoot and white clover, Jones has been able by grazing at certain periods to produce three different swards, each with one of these species dominant. This effect, though hastened by grazing with that purpose in view in the experiment, is no doubt responsible for a great deal of the alteration in composition of pastures which takes place on farms. The experiment was then continued with reversed grazing treatments on each plot and the swards were brought back to their original uniformity. We thus have in grazing management a most effective means of controlling pasture composition, and there appears to be a wide scope for definite information on its use. An elaborate experiment is being conducted by Davies at Aberystwyth on this problem at the present time.

One difficulty which occurs in all pasture management research is the relationship of the pasture being studied to the farm as a whole. It would be, for instance, of little value to advise a system of stocking which requires large numbers or the absence of stock when the economy of the farm does not allow it. An experiment by Martin Jones illustrates how this may be tackled. Time of grazing experiments showed that repeated heavy early grazing reduced the perennial ryegrass content of the sward. On the farm this cannot be avoided on many paddocks. A rotation was therefore devised so that early grazing on each paddock is restricted to the first two years. For the next two years of the rotation a silage or early hay cut is provided to allow for recovery. There are thus four large plots in the experiment, each one

representing one year of the rotation. Each large plot is subdivided for rotational grazing during its grazing time. It is thus hoped to maintain the stock almost wholly on the area and to maintain the balance of species under a condition of management applicable to the farm.

It is usually desirable to replicate experiments in several centres throughout a region. On his visit to Australia in 1931, William Davies[7] made a large number of observations in all States on the classification of our pastures on an ecological basis. This was followed by further work by the individual States, and the pasture map of Australia recently compiled by McTaggart[8] now provides a uniform basis for detailed surveys.

PASTURE SURVEYS.

Two types of pasture survey appear to be generally distinguished: the one aimed to produce an actual pasture map, the other an ecological pasture map. Davies has just completed one of the former type. This survey covers Wales in various degrees of detail, depending upon the economic importance of the area. The subdivisions and scales used are such that the work can progress conveniently from the general to the particular as required. A further example of the detailed survey was seen in New Zealand, where E. A. Madden is surveying the pastures of the Hawkes Bay district, showing individual paddocks.

The ecological pasture map would seem to be the most generally useful under Australian conditions. Pasture developments are extending so rapidly that an actual pasture map would in many areas soon be out of date. It is important, however, to know what proportion of the potential pasture zones are actually covered by the pasture indicated by the environment. It would therefore seem desirable that in addition to proceeding with more detailed charting of the pasture zones, actual pasture mapping should be carried out also. A skilled worker could probably obtain both lots of information at the one time. The most productive areas should probably receive such intensive work first.

The chief results of pasture research which are being adopted commercially in Great Britain are pedigree seed production and the artificial drying of grass.

From the Welsh Plant Breeding Station, three distinct strains of each of the chief pasture species are being produced. The seed is bulked up under the supervision of the seed production agronomist, Mr. G. Evans, who makes contracts with farmers, and organizes seed growing associations. Pedigree seed is also sold to merchants, who arrange for re-growing. Tests are in progress to determine the relative deterioration under both controlled and uncontrolled seed multiplication. In other centres seed firms are engaged in strain production, chiefly for local demand.

Artificial grass drying has originated from the work of Woodman, who has kept a sample of the first piece of grass cake made in 1927, thus showing its keeping quality. The dried grass being produced on farms is now compressed not into cakes, but into bales. The commonest type of drying plant at present is that developed by Imperial Chemical Industries. Drying takes place in two stages, one in each of two trays, where the herbage is subject to a current of hot air for twenty-five minutes. In another, more compact machine, the herbage is sucked through in a few seconds. As the herbage passes through the flame in this machine it is likely that digestibility might be slightly lowered, but its speed and compactness should make it very suitable for a portable plant.

The product has a protein content of about 20%, and is expected to sell at £7 per ton. It should therefore lower the cost of concentrates to the British farmer. On the individual farm, dried grass has most of the advantages of silage, and few of its disadvantages. It is much more convenient to handle, and can be used or sold in small lots.

Commercial results are expected in the improvement of hill grazing land, experiments on which are being conducted by Professor Stapledon[9] on a large scale in Wales. These areas previously carried a larger population than they do at present, the deterioration being considered due to the continual withdrawal of minerals from the soil and to the methods of grazing practised. It has been demonstrated that the production from this country can be much improved, but the cost at present seems such that it is only likely to be carried out widely under conditions of national self support.

In conclusion, the writer desires to acknowledge his indebtedness to the Director of Agriculture, Tasmania, and to Professors Wadham and Richardson for assistance in various ways connected with the tour abroad.

REFERENCES.

[1] Brenchley, W. E. The Influence of Season and of the Application of Lime on the Botanical Composition of Grass Land Herbage. Ann. Appl. Biol. XXII : 183–207, 1936.
[2] Yates, F. Complex Experiments. Supp. Jour. Roy. Stat. Soc. II : 2, p. 181, 1935.
[3] Cornish, E. A. Non-Replicated Factorial Experiments. Jour. Aust. Inst. Agric. Sci. 2 : 2, p. 79, 1936.
[4] Davies, W. Methods of Pasture Analysis and Fodder Sampling. Welsh P.B. Stn. Rept. No. 1, 1933.
[5] Jones, L. I. The Feeding Value of Pastures sown with different Strains of Grasses and Clovers. Emp. Jour. Exp. Agr. IV : 263–73, 1936.
[6] Jones, M. G. Grassland Management and its Influence on the Sward. Emp. Jour. Exp. Agr. I : Nos. 1, 2, 3, 4, 1933.
[7] Davies, W. The Grasslands of Australia and Some of their Problems. C.S.I.R. Pamp. No. 39, 1933.
[8] McTaggart, A. A Survey of the Pastures of Australia. C.S.I.R. Bull. No. 99, 1936.
[9] Stapledon, R. G., *et al.* Investigations on the Improvement of Hill Grazings. Welsh P.B. Stn. Bull. Ser. H., No. 14, 1936.

Defects in Eggs

SOME BACTERIOLOGICAL ASPECTS.

By

W. S. Sutton, B.Sc.Agr.,
Biological Branch, Department of Agriculture, Sydney.

In Australia egg production has developed from a more or less unimportant place in the routine of mixed farming into an industry of considerable importance in both local supply and export trade.

The highly nutritious nature of eggs, coupled with their particular value in influencing the physical properties of cakes, etc., has made them one of our basic foodstuffs. The natural result has been the establishment of grades of eggs and the recognition of various types of defects.

METHODS OF GRADING.

For market purposes, there is no more satisfactory method of grading eggs than by candling. This process readily detects the presence of foreign bodies, such as blood spots, moulds, and excessive air space, while it also demonstrates addling, floating yolk, and similar troubles. However, where more detailed information is required for research into the effects of such factors as environment, feed, etc., on egg quality, the measurements of shell porosity, determinations of yolk colour and the preparation of size indices, etc., necessitate measurements by means which are more technical than simple candling.

GRADES OF EGGS.

For general market purposes, eggs are divided into three grade types, but the designation of each type is not universally standardized. " First grade " usually refers to newly laid eggs of large size and clean appearance and good shell quality. " Second grade " generally includes eggs which are dirty or which contain inclusions of " foreign " material. Eggs with very slightly fractured shells are also placed in this group. " Rejects " are represented by eggs whose shells have been sufficiently fractured to cause leakage of albumen or whose contents have been addled by mechanical or biological means. The presence of moulds or any development of the germinal disc also relegates eggs to this class.

OCCURRENCE OF " REJECTS ".

Of the eggs handled by the Marketing Board in Sydney, it has been estimated that less than 3% are rejects. Many of these inferior eggs have,

of course, resulted from factors which are not bacteriological. And such factors are collectively more important than that of bacterial activity.

MECHANISM OF RESISTANCE TO INFECTION.

In fact, entire eggs are not a particularly perishable food. They are protected against the attack of bacteria by both physical and chemical means. The chief physical impediment to infection is the shell, which is of a permeable and porous nature, but is coated with a layer of gelatinous material. When dry, it inhibits contamination of the albumen and yolk. On the other hand, numerous investigators have succeeded in demonstrating the entry of bacteria through the shells of eggs submerged in liquid cultures of various organisms. Even under such conditions the penetration of the bacteria is slow, and thus tends to support the claim that in the majority of cases bacterial infection of the contents is effected through minute cracks in the shell. Some workers go so far as to claim that the unaltered shell is definitely impenetrable to bacteria, but the weight of evidence seems to be against this. The gelatinous covering is probably highly protective while it remains entire. Schrank[12] claims that the action of moisture removes the gelatinous covering from the shell and permits the entrance of bacteria through the pores. Zörkendörfer[18] states that both the shell and the shell membrane may be penetrated by micro-organisms.

The chemical nature of the albumen is inhibitory to the establishment of bacteria which may have passed through the shell. Sharp[13] has stated that whereas the hydrogen ion reaction of the albumen immediately after laying is in the region of pH 7·6, a rapid loss of carbon dioxide by diffusion into the air results in a pH of up to 9·7 in a few days. He claims that of all the factors involved in the natural preservation of eggs the hydrogen ion concentration of the albumen is the most important. Sharp and Whitaker[14] explain the inconsistent and often conflicting results published by other workers on the germicidal properties of egg white, as the outcome of failure to take into account the hydroxyl ion concentration of the albumen at the time of the experiment. However, Sharp and Whitaker[14] admit that there is apparently some other factor in raw egg white, in addition to the hydroxyl ion concentration, which affects the growth of bacteria. This latter finding is in agreement with the majority of other workers. Tanner[16] quotes Fleming and Allison as having demonstrated that egg white contains a bacteriolytic, bactericidal and bactio-inhibitory substance which they named *lysozyme*.

MODES OF INFECTION.

The question as to whether the egg may be infected before the formation of the shell is one on which there is a wide divergence of opinion. Tanner[16] quotes numerous authors as maintaining that the oviduct is not sterile. Rettger[11] states : " The contents of normal fresh eggs are, as a rule, sterile.

It is quite probable that an egg yolk may become invaded before it leaves the ovary; but this is apparently an uncommon occurrence except where the ovary is infected with the organism of bacillary white diarrhœa. Little, if any, infection takes place in the oviduct while the white and the shell are being deposited, on account of the protective action of the mucous lining and its secretions, and also the antiseptic and bactericidal action of the white itself." These conclusions are partly based on bacteriological examinations of ovaries and oviducts of laying hens. Lamson,[7] on the contrary, demonstrated the presence of bacteria in the oviducts of hens. Swingle and Poole[15] state: "Our evidence strengthens previous beliefs that some of the bacteria found in eggs gained entrance before the shell was formed, and some entered through the shell."

From the moment of being laid, eggs are likely to be contaminated. One conducive factor is the presence of droppings or of moist conditions in the nest. Zörkendörfer[17] stressed the importance of moisture in the infection of eggs, and demonstrated that most eggs kept in a moist chamber undergo offensive decomposition, while only a very small proportion of those kept in a dry atmosphere develop bacterial defects. Those specimens which deteriorated under dry conditions were probably contaminated before the commencement of storage. Experiments with inoculated eggs showed that the moisture content of the atmosphere neither inhibited nor accelerated decomposition by bacteria, which were already present in the albumen. Rettger[11] states that under normal conditions the shell is bacterium-proof. Moisture lessens its impervious character, however, and when combined with dirt or filth, makes it possible for bacteria to enter and bring about decay.

Conditions of moisture and temperature usually become most extreme during summer months. The occurrence of a greater proportion of infected eggs during this period is suggestive of the significance of this fact. The presence of a higher proportion of rotten eggs under brooding hens than in artificial incubators again indicates the importance of moisture in encouraging bacterial infection. It is the universal practice of egg dealers to discourage the washing of eggs for the reason that the trade believes that such treatment reduces the keeping quality of the egg.

Though the consensus of opinion is that in the majority of cases the contents of the egg are bacteriologically sterile, there is no doubt that the method of production is responsible for the contamination of the outer surface of the shell. Mauer[9] found colon bacilli on the shell of 77% of clean eggs, 82% of farm eggs and 100% of soiled eggs. A sterile egg which breaks in a package and leaks on to adjacent eggs will bring about the decomposition of the sound individuals by supplying the moisture necessary to permit the penetration of the shell by contaminating bacteria. Even when no "leakers" are present, it is necessary to pack eggs in containers through which air readily

circulates ; otherwise the high humidity which results will favour the development of defects due to the attack of bacteria and moulds.

TYPES OF BACTERIA IN EGGS.

It is fortunate that eggs are not affected by the great majority of bacteria. Lamson[7] claims that the fact that an egg contains bacteria does not mean that it is worthless. The question is mainly whether or not they are present in large numbers, and if present in small numbers are they likely to multiply ?

Swingle and Poole[15] isolated only those bacteria which they considered were responsible for spoilage, and identified *Bacterium alcaligenes*, *B. auranticus*, *B. cloacæ*, *B. coli*, *B. endocarditis*, *B. lactis*, *B. liodermos*, *B. megatherium*, *B. vitalis*, *B. vulgatus*, *B. wardii*, *B. zopfii*, *B. aerogenes*, *B. flexuosum*, *B. mycoides* and *B. verticillatum*. Rettger[11] found large proportions of staphylococci and the *B. subtilis* and *B. coli* groups, but claimed that they were probably derived from contamination. Other genera, including *Achromobacter* and *Pseudomonas*, have also been reported. Moulds are commonly encountered, and generally belong to the genus *Cladosporium* or *Penicillium*.

TYPES OF BACTERIAL DEFECTS.

The most generally recognized defect in eggs is that known as " rotten ". Benjamin[2] has recognized three stages of this condition. The " *white rot* " or " *sour egg* " is the first stage of bacterial decomposition, in which the contents have developed some degree of sliminess, are mixed and watery, and have a light yellowish colour. The egg usually has a sour odour. The " *mixed rot* " has watery contents in which various colours are usually mixed together. A mixed odour of sulphur and sourness may usually be detected. " *Black rot* ", the third stage, is characterized by a very distinct and offensive odour of sulphur. The yolk contents are of an oily, black colour. They are usually, but not necessarily, mixed with the albumen, which is very watery. Putrefaction of this nature may result from the action of a wide range of anaerobic and facultative anaerobic bacteria with proteolytic properties. Bennetts[3] found *Serratia* sp. to be responsible for the putrefaction of eggs.

"Mustiness"is another serious defect which has been reported from Australia and America. Affected eggs have a very characteristic odour which closely resembles that of a sprouting potato, but which is much more pungent and repulsive. Unlike rots, this defect is not detected by the candling process. The flavour is sufficiently penetrating to cause spoilage of considerable amounts of egg pulp or cake dough if an affected egg is inadvertently broken into the bulk. According to Conner,[5] if a musty egg is encountered while breaking eggs for freezing in China, the containers are " dumped " and the utensils are washed and sterilized.

Turner[17] reports an occurrence of mustiness in eggs due to an organism which he named *Achromabacter perolens*. Levine and Anderson,[8] in Iowa,

noted that the presence of a few musty organisms was sufficient to cause the defect.

It is of interest to note that Benjamin[2] and Pennington *et al.*[10] associate the occurrence of mustiness with damp conditions. In New South Wales a musty flavour in butter commonly occurs, and is due to the activity of an organism closely resembling *Achromabacter perolens* Turner. The butter organism has frequently been found associated with damp woodwork.

Anderson and Platt[1] have reported a condition which they term " floating and cloudy yolk " in eggs. The term has reference to the appearance of the egg during candling. On being broken, the contents, except the chalaza, appear to be fairly normal. There is no objectionable odour. A spore-bearing bacillus has been found to be associated with the condition, and has been isolated from the upper portion of the oviduct of a hen which was laying affected eggs.

METHODS OF PRESERVATION.

When stored in a dry place, uninfected eggs remain free from bacterial attack for an indefinite period. Unfortunately, under such conditions a drying down process occurs which finally results in desiccation.

Numerous methods of conserving moisture without encouraging bacterial activity have been employed in an endeavour to preserve eggs. The Board of Agriculture and Fisheries[4] list lime-water, water-glass and cold storage as effective measures. Another method which is widely recognized is the coating of the egg shell with special materials of a greasy nature. Lime-water and some of the greases are unsatisfactory. For home preservation purposes, Swingle and Poole[15] reported in favour of water-glass, in which the concentrated solution is used in 1 : 25 ratio with water.

Cold storage is increasingly popular in commercial circles. Unlike the above methods, it inhibits the development of bacteria within the egg. Lamson[7] states that bacteria which are commonly found in eggs do not multiply at low temperatures. An egg that is kept at 1·5° C. is safe from decomposition. Rapid growth does not occur until the temperature is raised to over 13° C. Griffiths, Villiers and Anderson[6] recommend that storage temperatures should be maintained as accurately as possible at 32° F. and that the humidity should not exceed 80%. The Egg Marketing Board of N.S.W. considers 32°-34° F. and 85%-87% humidity to be the optimum conditions for the transportation of eggs to overseas ports.

REFERENCES.

[1] Anderson, C. F., and Platt, A. E. Investigation into the condition known as " Floating and Cloudy Yolk " in Eggs. Jour. Dept. Agric. Sth. Aus. 39 : 11, 1342–1350, 1936.
[2] Benjamin, E. W. The interior quality of market eggs. Cornell Univ. Bull. 353, 1914.
[3] Bennetts, H. W. Specific putrefaction of hens' eggs due to *Serratia* sp. Aust. Vet. Jour. 7 : 27–31, 1931.

(4) Board of Agriculture and Fisheries. Preservation of Eggs. Leaflet 83, 1917.
(5) Conner, L. G. (Cited by Levine and Anderson.)
(6) Griffiths, E. A., Villiers, D. J., and Anderson, L. Note on the storage of eggs. Sth. Africa Sci. Bull. 41, 1925.
(7) Lamson, C. H. Infection and preservation of eggs. Conn. A.E.S. Bull. 55, 1909.
(8) Levine, M., and Anderson, D. Q. Bacteria causing mustiness in eggs. Jour. Bact. 23 : 337, 1932.
(9) Mauer, O. Bacteriological studies on eggs. Kansas A.E.S. Bull. 180, 1911.
(10) Pennington, M. E., *et al.* How to candle eggs. U.S. Dept. Agr. Bull. 565, 1918.
(11) Rettger, L. F. The bacteriology of the hen's egg, with special reference to its freedom from microbic invasion. Storr's A.E.S. Bull. 75, 1913.
(12) Schrank. (Cited by Rettger.)
(13) Sharp, P. F. The pH of the white as an important factor influencing the keeping quality of hens' eggs. Science 69 : 278–280, 1929.
(14) Sharp, P. F., and Whitaker, R. The relation of the hydrogen ion concentration of egg white to its germicidal action. Jour. Bact. 14 : 17–46, 1927.
(15) Swingle, D. B., and Poole, G. E. Studies in egg preservation. Montana A.E.S. Bull. 155, 1923.
(16) Tanner, F. W. The microbiology of foods. 1932.
(17) Turner, A. W. *Achromobacter perolens* (n.sp.), the cause of " mustiness " in eggs. Aust. Jour. Exp. Biol. and Med. Sci. 4 : 57–60, 1927.
(18) Zörkendörfer. (Cited by Rettger, also by Tanner.)

TECHNICAL NOTES

STUDIES ON " TAKE-ALL " OF WHEAT.—I.

Take-all, caused by *Ophiobolus graminis* Sacc., has long been regarded as one of the major diseases of wheat in Australia. The problem has been investigated by numerous workers in various countries, and the most important contributions in Australia in recent years have been made by Samuel, Garrett and Adam and Colquhoun[1] [4] [13] at the Waite Agricultural Research Institute. Portion of the writer's investigations on this disease, incidental to a general study of cereal root rots commenced in 1923, has already been recounted in a bulletin dealing chiefly with Helminthosporium root rot.[6] Unpublished data on certain aspects of the disease and its causal agent are presented in the paragraphs which follow.

ISOLATION OF PATHOGEN.

Isolation of *O. graminis* on agar media from infected wheat tissue, surface sterilized in mercuric chloride, has been found by the writer to be most difficult on account of the slow growth of this fungus and the frequent development of secondary, more rapidly growing organisms from diseased tissue. Kirby,[8] Russell,[12] Davies,[2] Garrett[5] and others report a similar experience, but the demonstration by Davies[2] of the superiority of silver nitrate over mercuric chloride for surface disinfection in the isolation of this organism from wheat tissue has simplified matters in this connection.

Most investigators, however, appear to use perithecial material in their attempts to obtain pure cultures of the pathogen. Kirby[8] immersed pieces of tissue bearing perithecia in a 1-2,000 mercuric chloride solution for one to two minutes, and then obtained single ascospore cultures by the dilution method. Methods tested in this connection by the writer several years ago involved procedures along the following lines :

(*a*) A small portion of a basal wheat sheath bearing mature perithecia and free from soil particles was crushed in a drop of sterile water on a glass slide, and a loop of spores then transferred to a second drop, from which a further loop was transferred to a third drop of water. Finally, from the latter a loop of spores was taken and placed in a tube of liquid 2% dextrose agar at 40° C., and the plate poured. Plates were incubated at 25° C. Also, ascospores from the first drop were tested for viability at room temperature in hanging drop cultures.

After four days, plates exhibited several colonies of *O. graminis*, each about 5 mm. in diameter ; very few contaminating colonies developed. The spores in hanging-drop cultures germinated vigorously.

(*b*) In this method, the procedure outlined above was followed, except that the sheath bearing the perithecia was first disinfected in 70% alcohol for one and a half minutes and then washed in sterile water. In another series the sheath was first placed in 70% alcohol for a quarter of a minute, then transferred to mercuric chloride (1-2,000) for one minute, and washed in sterile water prior to crushing on a slide.

After four days, none of the plates exhibited colonies of either *O. graminis* or contaminating organisms. Moreover, spores in hanging-drop from disinfected perithecia failed to germinate, while spores from untreated perithecia germinated vigorously.

It would appear, then, that the use of common surface sterilizing agents as alcohol and mercuric chloride are unsatisfactory and unnecessary in isolation work on perithecial material of *O. graminis*, and that the fungus can readily be isolated in pure culture by following the procedure detailed under (*a*) above.

PERITHECIAL FORMATION.

The development of perithecia on wheat plants under field conditions appears to be dependent on adequate supplies of moisture, for under New South Wales conditions at least it is quite common to find diseased plants in November exhibiting profuse development of plate mycelium, characteristic of *O. graminis*, but no perithecia. When the butts of affected plants are moistened, however, and placed in Erlenmeyer flasks under laboratory conditions, the fructifications soon develop.

The development of perithecia on agar media from known perithecial-forming isolates has been found by the writer to be extremely rare and sporadic. With a view, therefore, of providing conditions which might stimulate their

formation, five of these isolates were cultured on inverted funnels of filter paper in four-inch Petri dishes at 25° C. After placing the paper moistened with distilled water in the plates, 12 cc. of concentrated Raulin's solution or of Leonian's solution in concentrations of 1%, 2%, 5%, 10%, 25%, 50% and 100% were added to each dish, which was then autoclaved. Inoculations were performed by transferring agar plus mycelium to the apices of the paper funnels. All plates were kept under close observation for a considerable period, and although mycelial growth was quite vigorous in certain series, in no instance did perithecia develop. The strains used were known to fructify on wheat, and it is apparent from the work of the writer and others that the conditions governing perithecial formation in *O. graminis* are as yet imperfectly understood. Kirby[8] found that perithecia developed on crushed-wheat agar and on sterilized sweet clover and wheat stems, while Russell[12] observed that out of a variety of media tested, the only one upon which mature perithecia and ascospores developed was ground oat hulls. Both Kirby and Russell reported that some strains of the fungus produced perithecia more readily than others.

It may be argued that the failure of some isolates to fructify is attributable to heterothallism, but although Kirby[7] reported what he considered to be a demonstration of this phenomenon in *O. graminis*, the work of Davis[3] is contradictory. Moreover, in his later publication Kirby[8] states: "Further investigation will be necessary to determine whether or not the strains of this fungus can be segregated into definite sex types". There is no concrete evidence that heterothallism does exist in this organism, and the fact that some monosporous cultures of this fungus fail to develop perithecia appears to be due to lack of favourable conditions, rather than to innate inability of the cultures to fructify.

PHYSIOLOGICAL STRAINS.

No work has so far been published on physiologic specialization in Australian isolates of the take-all fungus. A study by the writer of the colony characters and rate of growth of several different monosporous cultures of the organism from wheat on potato dextrose agar, 0·2% dextrose agar, 5% dextrose agar, and 2% potato agar in four-inch Petri dishes at 26° C., showed that there were six distinct physiological strains. All work was done in triplicate, and each dish contained 20 cc. of medium. In all cases, the colony growth was flat and devoid of prominent development of aerial mycelium, and for the most part colonies were regular in outline; two strains on dextrose agar, however, were irregular in growth, the fringes of the colonies being fern-like in character. The principal features which served to differentiate strains were colour of colony, rate of growth, and discolouration of medium. Several of the cultural features noted by Kirby[8] were also observed by the writer. Potato dextrose agar was found to be a good differential medium, and the

outstanding features of the six strains on this preparation after seven days' growth are indicated in Table I.

Table I.—*Colony Characters of Six Australian Strains of* Ophiobolus graminis *on Potato Dextrose Agar after Seven Days' Growth at 26° C.*

Strain.	Colony Diameter. (Mm.)	Colony Colour.	Discolouration Medium.
A	25	Dull white.	Cream.
B	78	Dull grey.	Light greenish-grey.
C	80	Grey.	Greenish-grey.
D	77	Light greenish-grey.	Grey.
E	90	Dull grey.	Grey.
F	71	Greenish-grey.	Light brownish-grey.

The pathogenicity of these six strains of *O. graminis* was then tested in a replicated experiment under outdoor conditions in six-inch pots. Sterilized loamy soil was used, and inoculations were made by incorporating 190 cc. of inoculum with the top two inches in each pot, just prior to sowing. The inoculum was prepared by culturing each strain on a mixture of sterilized wheat and oats. The varieties of cereals used were: Hard Federation, Canberra, Marshall's No. 3 (wheat), Algerian, Lachlan (oats), Cape (barley), Black Winter (rye). Twenty grains were sown per pot at a depth of one inch, and the test was initiated on July 31. Adequate controls were provided in all cases. All pots were placed in a situation where the temperature conditions during early growth were favourable for disease development, and an effort was made to maintain a uniform condition of moisture in all series throughout the course of the experiment. The daily temperature range and average based on readings taken at 2 p.m. during the first month of the experiment were 52°-74° F. and 61·7° F. respectively; and during the second month, were 61°-96° F. and 72° F. respectively. Under the conditions of the experiment, the soil doubtless soon became contaminated by saprophytic organisms, and therefore the temperature optimum for infection was lower than it would have been had the soil not been subject to the influence of contaminants.[7] [9a]

The figures for emergence showed that the loss from pre-emergence blight was very small, so that this did not affect the final data on plant height accumulated for each pot at the time of maturity early in December. Four weeks after sowing, it was quite evident that infection had occurred in certain of the series, while at the seven-weeks stage 50% of the wheat plants in soil inoculated with strain B were dead as a result of the action of the pathogen. Examination of plants at maturity showed in the inoculated series that extensive rotting of roots had occurred, with practically no basal stem discolourations; premature ripening also occurred. It was quite evident

that the differences in pathogenicity of strains could best be assessed on the degree of stunting which developed, and the figures in Table II represent the average amount of stunting in inches as determined from the measurement data for all plants in both inoculated and control series.

Table II.—*Amount of Stunting (Inches) in Adult Wheat and other Cereals when Grown in Soil Inoculated with Distinct Strains of* Ophiobolus graminis.

Variety.	*Ophiobolus graminis* Strain.					
	A.	B.	C.	D.	E.	F.
Hard Federation Wheat	—	*a*	6	6	4	9
Canberra Wheat	2	*a*	—	4	6	4
Marshall's No. 3 Wheat	—	*a*	—	3	—	—
Algerian Oats	—	—	9	—	—	6
Lachlan Oats	—	—	—	—	—	3
Cape Barley	—	8	9	9	—	9
Black Winter Rye	6	6	6	3	6	3

a = Plants killed by pathogen in early growth stages.
— = No stunting occurred.

It is apparent from the results that each of the six cultural strains of the pathogen was distinct also in its effects on cereals. In general, strain B proved to be most virulent, while strain A was least virulent of the six tested Wheat, barley and rye were particularly susceptible to damage by the pathogen, while oats were resistant to four of the strains used. Under the conditions of the test there appeared to be varietal difference in wheat and oats to the effects of parasitic invasion.

Differences in pathogenicity of different isolates of *O. graminis* have been reported by Davis,[3] Moritz,[10] Russell,[12] Simmonds,[14] Krebs,[9] Padwick[11] and the writer.[6]

H. J. Hynes.

Biological Branch,
Department of Agriculture,
Sydney, N.S.W.

REFERENCES.

[1] Adam, D. B., and Colquhoun, T. T. The spread of take-all through the soil. Jour. Aust. Inst. Agric. Sc. 2 : 172–174, 1936.
[2] Davies, F. R. Superiority of silver nitrate over mercuric chloride for surface sterilization in the isolation of *Ophiobolus graminis* Sacc. Canad. Jour. Res. 13 : 168–173, 1935.
[3] Davis, R. J. Studies on *Ophiobolus graminis* and the take-all disease of wheat. Jour. Agric. Res. 31 : 801–825, 1925.
[4] Garrett, S. D. Factors affecting the severity of take-all. Jour. Dept. Agric. S. Aust. 37 : 664–674, 799–805, 976–983, 1934.
[5] ———— Soil conditions and the take-all disease of wheat. Ann. App. Biol. 23 : 667–699, 1936.

(6) Hynes, H. J. Studies on Helminthosporium root rot of wheat and other cereals. N.S.W. Dept. Agric. Science Bull. 47, 1935.
(7) Kirby, R. S. Heterothallism in *Ophiobolus cariceti*. Abst. in Phytopath. 13 : 35, 1923.
(8) _____ The take-all disease of cereals and grasses caused by *Ophiobolus cariceti*. Cornell Univ. Agric. Experi. Sta. Mem. 88, 1925.
(9) Krebs, J. The influence of soil temperature on infection of wheat seedlings by *Ophiobolus graminis*, the agent of blackleg. Abst. in Rev. App. Mycol. 13 : 224, 1934.
(10) Moritz, O. Weitere studien uber die Ophiobolose des Weizens. Arb. Biol. Reichsanst. fur Land-und Forstwirtsch 20 : 27–48, 1932.
(11) Padwick, G. W. Biologic strains of *Ophiobolus graminis* Sacc. Ann. App. Biol. 23 : 45–56, 1936.
(12) Russell, R. C. Studies of take-all and its causal organism, *Ophiobolus graminis*. Dom. of Canada, Dept. Agric. Bull. 170, N.S., 1934.
(13) Samuel, G., and Garrett, S. D. Ascospore discharge in *Ophiobolus graminis*, and its probable relation to the development of whiteheads in wheat. Phytopath. 23 : 721–728, 1933.
(14) Simmonds, P. M. Report of Dom. Bot. for year ending 1928. Div. Bot. Canad. Dept. of Agric., 91–107, 1929.

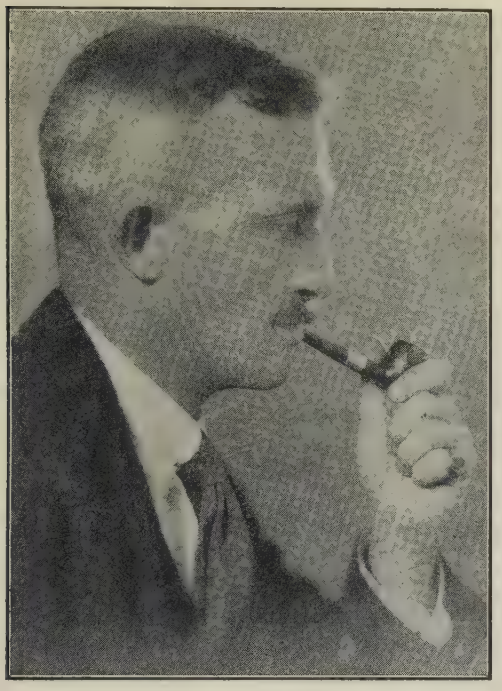
The Australian Institute of Agricultural Science

THE NEW PRESIDENT.

At the first general meeting of the Institute, held at Science House, Sydney, on January 6 and 7, 1937, Professor S. M. Wadham, M.A., Dip.Agr., Professor of Agriculture in the University of Melbourne, was elected President for the ensuing two years.

Since his arrival in Australia in 1926, Professor Wadham has evinced a keen, practical interest in agricultural affairs generally in this country, and has been closely identified with several important inquiries of a national character. His wide and intensive knowledge of the problems of agriculture, his refreshingly practical point of view, and his keen sense of humour have won for him the admiration and esteem of his colleagues throughout Australia. We wish for our new President a happy and successful period of office.

Professor Wadham was born in Ealing, London, in 1891, and was educated at Christ's College, Cambridge, where he obtained a first class in both Part 1 and Part 2 of the Natural Sciences Tripos, and secured the Cambridge Agricultural Diploma in 1913. He was awarded a Research Scholarship by the Board of Agriculture and Fisheries, and proceeded to Germany to begin work in June, 1914. During the Great War, he served with the London Regiment, the Durham Light Infantry and the Signal Service (R.E.). Subsequent to holding various teaching and research appointments at Cambridge, he was appointed in 1926 to the position he still occupies. In 1928 he was commissioned by the Council for Scientific and Industrial Research to report on the technical aspects of dairying in eastern Australia, and in 1929–30 was a member of the Federal Dairy Investigation Committee. In 1934 he was appointed as one of five Royal Commissioners to investigate the wheat, flour and bread industries of the Commonwealth ; this work took most of his time from January, 1934, to January, 1936. In 1936 he was appointed a member of the Commonwealth Advisory Council on Nutrition. He is at present a member of the Councils of Melbourne University and the Royal Agricultural Society of Victoria.



PROFESSOR S. M. WADHAM,
M.A., Dip.Agr.

President of the Australian Institute of Agricultural Science.

CONSTITUTIONAL REFORM

By

G. DE V. DAVIS, B.Sc.Agr.

The first general meeting of the Institute was, as has been mentioned elsewhere, devoted almost entirely to the consideration of the Memorandum and Articles of Association under which the body is governed. Some disappointment may have been felt at the absence, apart from the Presidential Address, of any technical communications. It must, however, be remembered that the value and the length of the future of the Institute depend solely upon its power to attract to its membership all who practise the profession of Agricultural Science. It would be idle to deny that, great as has been the success of the Institute from the statistical standpoint, there has been some dissatisfaction both, within and without the body, at certain of the Laws. That this may have prevented the attainment of even a bigger membership must also be admitted. Thus, with the perfection of a Constitution one can look for universality of membership and to general meetings where the science, rather than its practitioners, will be discussed.

For this reason, if for no other, it will be of interest to mention some of the more far-reaching changes that were proposed. In the first place, thanks to the work of the Federal Capital Territory Branch, the original documents were rearranged so that matters dealing with various aspects of a given subject were placed in juxtaposition and the whole of the subjects ordered in a natural sequence.

The first section of the new Articles, after a few formal clauses, deals with membership. Under this head fall such matters as qualifications for and methods of admission. The privileges of members of various classes are next detailed, after which the rules concerning

the formation and management of branches are stated. Next comes the section dealing with the management of the Institute, the election of members of the Council, and their joint and several duties. The control of the Journal, clauses detailing the financial obligations of members, and the new and vital clauses governing the alteration of rules complete the document, which is, in all probability, to be put before all members for ratification in the immediate future.

Dealing now with details of the alterations to the original Articles, it will be of outstanding interest to members to learn of the elimination, with one exception, of all distinctions between those who have and those who have not graduated from a university. Even the one remaining difference is more apparent than real. A graduate in Agricultural Science is eligible for membership, not *ipso facto*, but only provided he is engaged in work of a nature acceptable to the Council. A graduate in any faculty other than Agricultural Science, to attain eligibility must, for a period of at least two years, have been engaged in such "acceptable" work. An applicant who possesses no degree needs to have been engaged in work of the acceptable type for five years before being eligible. Apart from the more obvious reason for this distinction between the various classes, it must be pointed out that a graduate in Agricultural Science has spent four years or more in studying the principles of the science, and this is broadly equal to the period of qualification asked from a practitioner of the science who has not had the university training.

Once the matter of eligibility for membership has been passed, no differences exist as between one candidate and another. Foundation members are defined as all who joined prior to January 1st, 1937. Thenceforward, all candidates for admission need the endorsement of six corporate members, must submit evidence of eligibility to the committee of the Branch through which membership is sought, and must submit to an election by members of the Council, two-thirds of whom must vote in their favour. Again, and for emphasis, it must be noted that this procedure will be followed in the case of any candidate, whether he be a professor or any other more or less eminent member of the profession.

Honorary membership, which is defined as being awarded for eminent services, is safeguarded by regulations which call for a nomination from at least twelve members and a nine-tenths majority vote of members of Council.

Under the heading of Branches is an important alteration. Formerly, Branch constitutions were defined as being necessarily " compatible " with that of the Institute. Now the Branches must actually operate under the Constitution, though they retain the right to frame by-laws, which must not, however, infringe the Constitution.

The most drastic alteration of all was in connection with the body of management, in future to be known as, simply, the Council. Whereas formerly Branch representation was on a basis of one Councillor for each twenty-five members, with a maximum of four Councillors from any one Branch, in future each Branch will have one representative only. Each Councillor who resides in any centre away from the office of management is entitled to appoint a personal " proxy," who will attend all Council meetings. Thus, instead of the Institute being controlled by an executive committee—as, with such brilliant success, in the past two years—it will be controlled by a council of elected members (or representatives appointed by the elected members and, therefore, having similar views).

The President is, in future, to be appointed by the retiring Council from amongst past or present Presidents of the Institute or any of its Branches. The Honorary Secretary and the Honorary Treasurer for any term shall be appointed, from the members of the Branch in whose territory the Office of Management is located, at the first meeting of the Council after any general meeting.

Thus, the Council as a whole will consist of ten members—the Editor of the Journal no longer retaining his *ex officio* seat—and it is considered that regular and fully attended meetings of Council will thus become possible.

Where a matter comes to a vote at a meeting of Council, it has been laid down that the Branch representatives, or, in practice, their proxies, shall be entitled to one vote for each financial corporate member of the Branch they represent, with the notable exception of the election of candidates for membership, at which the Councillors vote as individuals.

Whilst other alterations of major or minor importance were effected, the foregoing covers all the matters of most direct interest to members except the clause previously mentioned, governing the machinery for altering the Constitution.

This makes it possible for private members attending future general meetings to introduce matters, not necessarily duly notified sixty days before the meeting, for the consideration of the meeting, and a simple majority of those present may declare such matter to be duly notified. There is a proviso, however, to the effect that any such business may be declared by any one member of the Council to be so revolutionary—" materially affect the sense of the Constitution " is the formula adopted—that it demands the scrutiny of individual members, and it must then be made the subject of a postal ballot. This whole article gives much more flexibility to the organization, whilst protecting the Institute, through the proviso, against the possible harm that might result from hasty or ill-considered legislation.

As was indicated before, the whole text of the new Constitution is likely to be submitted to all members for ratification. This, incidentally, will be done under the proviso of the Article last described. This opportunity is taken to indicate to those who will be voting for the acceptance or rejection of the document as a whole, that it now stands as the result of two years of intensive debate prior to the formation of the Institute and two years of practical experience of the management of the existing body. It has been subjected to the scrutiny of most of the members who have been active in the management, and it can be confidently recommended for acceptance on the grounds that it is practical, that it is Federal in outlook, that it is democratic, and, above all, that it can be readily amended in the future should experience show flaws that are not presently apparent.

FIRST GENERAL MEETING.

The First General Meeting of the Institute was held at Science House, Sydney, on January 6 and 7, 1937, Canberra and all States being represented. The Council meeting took place at 10 a.m. on the 6th, and 19 delegates were present; the President (Professor Richardson) occupied the chair. Reports by the Secretary, Treasurer, Editor and Business Manager were read to Council, and these, with the exception of the Treasurer's statement, which will be published when the audited balance sheet is available, appear in the following pages.

Several points of discussion arose from the reports, and amongst the decisions reached by Council the following were the most important: (1) Rebate to Branches to be on same basis as in 1935, viz. 5/6 *per capita*. (2) Annual sum of £30 to be granted to the Editor for use in any way connected with his editorial duties. (3) Size of Journal to be increased by approximately 12 pages per issue, and the number of copies published to be increased by 100 in future. (4) Additional funds be made available for production of the Journal. (5) A committee comprising the Editor, Business Manager and President of the N.S.W. Branch to meet and discuss possibilities for securing better terms in respect of publishing the Journal, to inquire into facilities for storing files and back numbers of the Journal, and to consider the appointment of an Assistant Editor. (6) Local Branches to endeavour to purchase from their members issues of Volumes 1 and 2 of the Journal, required for binding purposes. (7) The retiring Auditors of Institute and Journal accounts be re-elected.

The General Secretary, General Treasurer, Editor and Business Manager were each re-elected for the ensuing two years.

The General Meeting commenced its session on January 6 at 2 p.m., and the whole of the business was concerned with revision of the Constitution. The discussions were continued on January 7, and on the afternoon of that day the Drafting Committee (consisting of Professor Wadham and Messrs. Vasey, Davis, Piper, Teakle, McMillan, Scott and Hughes) met to prepare the Memorandum and Articles of Association based on decisions reached in the General Meeting. An account of the more important changes effected is given in the article on " Constitutional Reform " by Mr. G. de V. Davis in this issue. The new Constitution does not become official until it has been circulated to members and approved by the necessary majority of them by postal vote.

The Presidential Address was delivered by Professor A. E. V. Richardson at Science House on the evening of January 6, and at its conclusion was thrown open for discussion. Votes of thanks were proposed by Professor J. A. Prescott and Dr. B. T. Dickson. The chairman, Professor R. D. Watt, then invited all members to be present at the supper party at the Wentworth Hotel, arranged by the N.S.W. Branch.

At various times throughout the two-day conference appreciative references were made by Councillors and members to the excellent service rendered to the Institute in its first two years by the President (Professor Richardson), Secretary (Mr. Vasey), Treasurer (Mr. Twentyman), Editor (Dr. Hynes), Business Manager (Mr. Edwards), the Executive Committee, and others associated in various ways with the workings of the Institute.

REPORT OF EXECUTIVE COMMITTEE.

Your Executive Committee has pleasure in presenting its report covering the Institute's second year. You have already been informed of the Committee's activities by means of the circulation of the minutes of its meetings, so it is not intended to discuss these in detail, but rather to touch briefly on certain important points.

The same general policy has been pursued in 1936 as in the initial year, viz., the strengthening of Local Branch proceedings, and the use of the Journal as the chief co-ordinating medium.

The relations with the Local Branches have been of the happiest, and your Committee takes this opportunity of offering its congratulations to all office-bearers on the high standards achieved in Branch meetings. In regard to matters of organization, the Honorary Secretary wishes to express his appreciation of the efficiency and enthusiasm of his Branch colleagues.

At November 30, 1936, the membership of the Institute stood at 330 corporate members and 21 student members, the constituent Branch totals being as indicated in the accompanying table.

As the term is defined by Article 23, there were at this date no unfinancial members. The slight amount of defection that has occurred, however, will be indicated to you by the Honorary Treasurer in his financial statement. Of the corporate members, 36 were persons other than graduates, and were elected under the provisions of Article 5, Clause (*a*), Section 4.

The Institute's Journal goes from strength to strength, and once again the Committee wishes to record its grateful appreciation of the work of Messrs. Hynes and Edwards, the Editor and Business Manager, respectively. Separate reports will be presented by these gentlemen later in this meeting.

TABLE SHOWING INSTITUTE MEMBERSHIP IN EACH OF THE SEVEN CENTRES OF THE COMMONWEALTH, TOGETHER WITH THE TOTALS FOR 1935 AND 1936.

Branch.	Corporate Members.	Student Members.
New South Wales	83	1
Victoria	75	10
South Australia	51	5
Queensland	39	
Western Australia	37	5
Federal Capital Territory	28	
Tasmania	17	
Total (1936)	330	21
Total (1935)	287	22

As you are aware, the first meeting of the Federal Council was held in Melbourne on June 3. Full details of all business to be considered thereat was circulated to all delegates to permit of postal voting. The minutes of the meeting were similarly circulated. Steps were taken to give effect to all decisions recorded, the required notice of the calling of the first general meeting was published in the September issue of the Journal, and the associated actions prescribed in the relevant Articles of the present Constitution undertaken. A special report on the result of the ballot for the election of office-bearers is attached to these papers. Full details of notices of motion received for alterations to the Constitution were circulated to all Branches, and a summary of same prepared for the business paper of the general meeting.

In accordance with the decision of the last meeting of the Council, no action has been taken in regard to affiliation with the Federation Internationale des Techniciens Agronome. The secretary of that organization, however, writes regularly, and his letters are of interest in supplying details of current European thought on professional matters.

Seven Committee meetings were held during the past year, at which the average attendance was six members. The President was present at all meetings, and your Committee wishes to express its deep appreciation of his continued interest and enthusiasm.

For and on behalf of the Executive Committee,

A. J. Vasey,
Honorary Secretary.

REPORT OF THE EDITOR

The Journal of the Australian Institute of Agricultural Science first appeared in March, 1935—just two months after the inaugural meeting of the Institute—and has been published at quarterly intervals since that time. The policy and general format of the Journal as incorporated in the original number have not been departed from in any of the subsequent issues. The aim at all times has been to make the Journal something more than a mere record of results of scientific research : rather to fill the greater portion of each issue with articles of general appeal to members, brief technical notes on experimental studies, together with leading articles, book reviews, proceedings of branches of the Institute and of other agricultural scientific bodies, professional news and personal notes. The conduct of the Journal along these lines has involved considerable effort in organization and editorial attention for each issue—more so than would have been demanded in the case of a strictly research publication. But in view of the comments of members generally and of editors of several overseas journals, there appears to be full justification for continuance of the original policy laid down two years ago. It is hoped, however, that as time goes on there will be still further evidence of development and progress in the Institute's official publication.

The first volume contained 184 pages, the second 189 pages, an index for the year being included with the issue of each of the December numbers. The final number of Volume 1 also contained a list of members of the Institute and their addresses. In the two volumes there have been published thirty-nine articles, thirty-seven technical notes, nine book reviews, eight editorials and numerous items of professional and personal interest. The book review section was inaugurated with the first number of the second volume, and was made possible by the ready response of book publishing companies in England and the United States to representations made in January, 1936. Had space permitted, there would have been reviews of six new books in the December number just issued, instead of two which appeared. There never has been difficulty in securing sufficient matter to fill the allotted forty-four pages of each issue. On the contrary, publication of articles has in many cases had to be delayed through pressure of space. A larger volume could readily be maintained if funds permitted.

The literary standard of manuscripts submitted for publication has for the most part been very satisfactory ; only in a few cases was it necessary practically to re-write an article. Of all the articles forwarded, three only were rejected.

Following the appearance of the first number, an effort was made to secure exchanges with other agricultural scientific publications, and to date twenty-five periodicals are received regularly from various parts of the world. Arrangements were also made with the editors of some fifteen overseas abstracting journals to review articles and technical notes published in the A.I.A.S. Journal. The number of periodicals and new books so far received has not caused any undue tax on one's personal library shelving, but this is a matter which will require attention in the near future if these publications are to be regarded as Institute property (as they should be) and not the property of the editor. The inclusion in the Memorandum of Association of a " library clause " appears now to be well worthy of adoption.

In conclusion, it is desired to acknowledge gratefully the valuable and generous assistance given at all times by the sub-editors in the several branches of the Institute. Without their persistent and painstaking efforts it would have been impossible to provide members with the type of journal which they now receive.

REPORT OF THE BUSINESS MANAGER.

The final mailing lists for 1936 show that the Journal was distributed in that year as follows: New South Wales, to 83 members; Victoria, to 83 members; South Australia, 52; Western Australia, 43; Queensland, 39; Canberra, 29; Tasmania, 17; oversea members, 5; exchange and abstracting journals, 38; libraries and newspapers, 25; subscribers, 12. Grand total, 426. In addition, 35 copies of each issue were distributed to Branches of the Institute. Complimentary copies are forwarded to the authors and publishers of books reviewed in the Journal, and six copies of each issue are filed with the Editor. Thus, of the 500 copies of each number printed, approximately 470 are distributed.

The number of reserve copies of each issue on hand at December 31, 1936, were as follows: Vol. 1, No. 1, 22 copies; Vol. 1, No. 2, 16 copies; Vol. 1, No. 3, 50; Vol. 1, No. 4, 45; Vol. 2, No. 1, 30; Vol. 2, No. 2, 34; Vol. 2, No. 3, 36; Vol. 2, No. 4, 31.

Reprints of 25 articles from Volume 2, amounting to 4,150 separates, were issued to authors. The costs in all cases were borne by the individual authors or by the institutions by whom the authors were employed.

Subscriptions and sales for the year amounted to £7 14s., and three subscription accounts are still outstanding.

The gross cost of publishing Volume 1, 1935, was £119 19s. 7d., and the net cost to the Institute was £96 3s. 8d., the difference being due to subscriptions and sale of reprints.

The actual gross cost of the March, June and September issues of Volume 2, and the estimated cost of the December issue amount to £153. This amount is offset by the sum of approximately £42 arising from subscriptions, and the sales of reprints and back numbers. The net cost to the Institute for the publication of Volume 2, 1936, will thus approximate £111.

In conclusion, the following matters are respectfully submitted for the consideration of Council: (1) That approval be granted for the publication of at least 100 additional copies of each future issue of the Journal. (2) That in view of the fact that the normal Institute expenditure on the Journal approximates £100 per annum, approval be granted to the Honorary Treasurer to increase the quarterly remittance to the Business Manager from £20 to £25. (3) That consideration be given to the provision of storage space for back numbers of the Journal, and also for the housing of the various record books and files concerning Journal production which are required either by the Editor or Business Manager.

REPRINTS OF ARTICLES.

Reprints of articles published in this Journal are available at the rates set out hereunder. The attention of authors is directed to the fact that no responsibility is taken for supply of reprints *unless* orders are forwarded with the manuscripts.

Number of Pages.	Number of Copies of Reprints.			
	100	200	300	500
1	13/6	15/6	17/6	19/6
2	16/–	18/6	20/6	22/6
3–4	23/6	27/6	30/6	33/6
5–6	30/6	35/6	40/6	45/6
7–8	37/6	42/6	47/6	52/6
9–10	44/6	50/–	55/–	62/6

Current Notes and News

INTERSTATE CONFERENCE OF CEREAL CHEMISTS.

Following upon a suggestion made by the Minister for Agriculture in South Australia, one of the items for consideration by the Standing Committee on Agriculture at the last meeting of the Australian Agricultural Council was " Standard Methods of Testing Wheat and Flour for Quality." It was decided that an interstate conference should be held in Sydney at a date to be fixed.

The conference was held on November 30th and December 1st and 2nd, 1936, the purpose being to discuss the possibility of standardizing technique and methods of analysis used in cereal chemistry. Those present were : E. H. Gurney (Queensland), W. R. Jewell (Victoria), C. E. Chapman (South Australia) and E. Griffiths and L. S. Cayzer (New South Wales). Representatives from Western Australia and Tasmania were unable to attend the conference.

With regard to experimental milling, it was agreed that the lack of uniformity in the mills in use in the various States made the adoption of a standard flow sheet impracticable, but a standard conditioning treatment was agreed upon. All wheats are to be conditioned in the cold to 13·5% moisture at least twenty-four hours before milling and half an hour prior to milling a further quantity of water is to be added to bring the moisture content to 14%, 15% or 16%, depending upon the hardness of the sample.

The standard baking test adopted was that of the National Research Council of Canada, with the following alterations :

(*a*) That the use of a minimum quantity of dusting flour at time of panning be permitted.

(*b*) That 0·5% malt flour may be used in place of malt extract.

(*c*) That allowance be made for three baking procedures, namely " basic," " malt phosphate " and " malt-phosphate bromate," with a recommendation that the " malt-phosphate " be adopted as the standard.

(*d*) That further modifications such as additional bromate, altered fermentation time, etc., are sometimes necessary if it is desired to specify the optimum conditions for a particular flour.

It was decided that the water absorption of a flour should be the percentage of water (based on flour at 13·5% moisture content) necessary to provide a dough of the correct consistency at panning, and that this can only be determined in conjunction with a baking test. The result is to be expressed to the nearest 0·5%.

It was further agreed that all analytical results should be expressed on a 13·5% moisture basis.

Diastatic activity, Farinograph tests and the wholemeal fermentation test of Pelshenke were discussed, and standard procedures decided upon. In the instance of the Farinograph, the conference adopted a standard method for recording results whereby the main characteristics of a Farinograph diagram may be described without recourse to the diagram itself.

With regard to gluten tests, it was generally agreed that although this test has its limitations, it is nevertheless of considerable value. A standard method for the determination of gluten was arrived at, a 0·1% sodium chloride solution being adopted as the wash liquid in preference to the solution of Dill and Alsberg, on account of the expense involved in the use of the latter.

The desirability of a collaborative study on the determination of gluten by the method adopted was realized, and it was decided that each State should select three flours for distribution to the other States for this purpose. The results are to be sent to L. S. Cayzer (New South Wales) for collation.

FOURTH INTERNATIONAL GRASSLAND CONGRESS.

The Fourth International Grassland Congress is to be held in Great Britain in July, 1937, under the presidency of Professor R. G. Stapledon, C.B.E., M.A., Director of the Welsh Plant Breeding Station and the Imperial Bureau for Herbage Plants, Aberystwyth, Wales. The previous congresses in this series have been held in Europe, and membership was more or less confined to European members, but delegates will go to this Fourth Congress from Great Britain, the British Dominions and Colonies, U.S.A., and numerous other countries which are members of the International Grassland Congress Association (Central Office in Leipzig, Germany).

The paper reading sessions will be held in Aberystwyth from July 13th to 19th, but intending participants will be able to join in a tour of centres of grassland interest and selected farms both before and after these sessions.

The fee for the Fourth Congress is two pounds sterling, which will entitle members to attend all sessions and to receive the printed transactions, including all abstracts in advance, of the Congress meetings, and any other incidental matter relating to the Congress. The Congress fee for wives accompanying members will be one pound sterling, and will admit to full membership, but will not entitle such members to receive a copy of the transactions.

The paper reading sessions to be held in Aberystwyth will be divided into three plenary and two sectionalized sessions. The sectionalized sessions will deal with the following aspects of the grassland problem: (1) Ecology (including surveys), pasture and range management (including erosion control). (2) Seeds mixtures (including lucerne for grazing), legumes for use in poor pastures. (3) Plant breeding, genetics, and seed production. (4) Manures and fertilizers. (5) Nutritive value of pastures, fodder conservation. (6) Grassland economics.

All particulars regarding the acceptance of papers and dates for receipt of abstracts and paper manuscripts may be had from the Joint Secretaries, Agricultural Buildings, Aberystwyth, Great Britain, to whom requests for the preliminary programme and application form for membership and all other correspondence regarding the Congress should be addressed.

Book Reviews

The Cultivated Races of Sorghum, by J. D. Snowden, F.L.S.

(Pp. 272, with 31 figures. Printed for the Trustees of the Bentham Moxom Fund by Adlard and Son, Ltd., London, 1936. Price, 10/6.)

In " The Cultivated Races of Sorghum " Mr. J. D. Snowden has accomplished the difficult task of systematically arranging and revising that important agricultural group of crop plants. The cultivated sorghums have long been regarded simply as varieties of *Sorghum vulgare* Pers., and were thought by some writers to have been derived from the wild *Sorghum halepense* Pers. Although the origins of many of the species enumerated in this work are still obscure, evidence is given which indicates the probability of several wild species being concerned in their evolution.

Mr. Snowden has examined a very extensive range of material, mostly from Africa, India, and Europe. In the past, characters of the panicle have been used as important diagnostic features, but as these have proved unreliable owing to the variation which may appear even in panicles of crops raised from the seed of a single head, other more constant characters have been sought. He has, however, found a considerable range in the shape and size of the fertile spikelets and grains, the texture of the glumes and grains,

and the relative size of the glumes and grains, which form a more reliable basis of classification. Consequently he has felt justified in describing many well marked forms as species, each with a number of varieties, and some of these again with several forms, the latter usually separated on the colour of the glumes and fruit. He argues that " where such differences are observed in wild grasses, particularly those occurring in widely separated areas, botanists have no hesitation in according specific rank to the most distinct types. To sink such distinctive races of cultivated Sorghums all under one species is a decided retrograde step, which possesses no advantages whether from the standpoint of the practical cultivator, the geneticist, the cytologist, or the systematist. Recognition of the most distinct races as species has the advantages of simplicity and directness." Duplication of varietal names has been carefully avoided so that those who may prefer to continue to consider all the forms as varieties of *S. vulgare* will still find this work of very considerable value.

The keys to the species and varieties, with detailed descriptions of each, will be of great practical value, especially as each species is admirably illustrated with figures of its spikelet characters. Historical and taxonomic notes give full details of the synonymy of each species, while cultural and economic notes appended in each case will be of much service to the practical man. Separate indices of vernacular names, botanical names, and countries and regions will be much appreciated, and an intensive bibliography of the more important literature on the genus is given. While, doubtless, economy of space had to be considered, it is perhaps unfortunate that the size of print used for the greater part of the book, and especially for the keys, is so small. Although the varieties of Sorghum introduced into Australia will doubtless be found to correspond with those described in this work, it is to be regretted that complete material from Australia was not available to Mr. Snowden when he was preparing his monograph.

This work will form a very welcome handbook to those interested in the genus *Sorghum* from various aspects. Mr. Snowden is to be congratulated on a very comprehensive monograph.

JOYCE W. VICKERY.

Growing Pastures in the South, by Joseph F. Combs, B.S.

(Pp. ix+270, with 9 tables and 78 illustrations. Chapel Hill: The University of North Carolina Press, 1936. Price, 2·00 dollars.)

Text books relating to pastures are so rare that the appearance of any treatise on pasture improvement becomes a notable event. Unfortunately, however, the few reference books available are purely botanical or tend to be practical compilations based on local observation and experience. Considerable progress has been made recently in attaining a less empirical outlook on grassland problems, but the universal text book, in which taxonomy, applied ecology and advanced practical methods are reconciled, has still to be written.

Mr. Combs's book, like its predecessors, is a compendium of observational information. It summarizes the author's experiences as Pasture Crop Specialist and Agricultural Extension Agent of the United States Department of Agriculture for seventeen years. While hailed in America as the only comprehensive treatment of the subject that has been seen, the book is of value chiefly as a practical treatise for farmers, extension officers and students located in the Southern United States.

The region concerned is characterized by a temperate climate, fertile soils and abundant rainfall; and a wide variety of pasture species can be grown. Twelve chapters are devoted to notes on the occurrence and practical value of numerous grasses and legumes; five chapters deal with the importance of pastures, their fertilization, management and utilization, preparation of the soil for planting, and the control of weeds. The

inoculation of pasture legumes is also discussed, and the final chapter provides a series of seeds mixtures for varying soil conditions in the different States.

At the conclusion of the various chapters references, totalling 86 in all, are given, and the majority of these are of American origin ; the reference to subterranean clover is a Texas publication. Perennial rye-grass is said to be a biennial or short-lived perennial, " but usually an annual in the South." In regard to weed control, grubbing, mowing, grazing and spraying are emphasized ; there is little or no evidence of the ecological concepts of competition and suppression by pasture species in an altered environment. The tables supply evidence of high production from pastures. The photographs are, in the main, excellent. The book is of value to Australian agrostologists in supplying a record of American experience with pasture species which also occur in the Commonwealth.

H. C. TRUMBLE.

Obituary

ROBIN JOHN TILLYARD.

The passing of Dr. R. J. Tillyard on January 13, 1937, as a result of a motor accident near Goulburn, has removed one of Australia's most brilliant scientists—one who achieved an international reputation for his eminent contributions in the field of entomology, and who won some of the most important honours which scientific bodies of the world can confer. He was handicapped throughout life by a long series of accidents and ill-health, but his successes in so many directions testified to his remarkable intellect and his indomitable perseverance.

Dr. Tillyard was born at Norwich, England, fifty-six years ago, and was educated at Cambridge, where he obtained the M.A. degree in mathematics in 1903. He also studied Oriental languages and theology. Owing to rheumatism, however, he was compelled to leave England, and in 1904 joined the staff of the Sydney Grammar School, teaching science and mathematics. In 1914 he graduated Research B.Sc. at Sydney University, and D.Sc. in 1917. Subsequently he held a Linnean Macleay Fellowship in Zoology, a lecture. ship in Zoology at Sydney University, and in 1920 was appointed Chief of the Department of Biology in the newly-formed Cawthron Institute for Scientific Research, Nelson, New Zealand. In 1928 Dr. Tillyard returned to Australia to become Chief Commonwealth Entomologist under the Council for Scientific and Industrial Research, and built up the Division of Economic Entomology stationed at Canberra. He resigned from this position in 1934, owing to ill-health, but continued to take an active part in several important movements.

Dr. Tillyard visited Europe and America on several occasions for purposes of research and attendance at international science congresses. Of the many honours conferred upon him, the following may be mentioned : F.R.S., London ; Sc.D., Cambridge ; Crisp Prize and Medal by the Linnean Society of London ; Trueman Wood Medal by the Royal Society of Arts and Science, London ; Honorary Fellow, Queen's College, Cambridge ; R. M. Johnston Memorial Medal by the Royal Society of Tasmania ; Clarke Memorial Medal by the Royal Society of New South Wales.

Apart from his work at Cawthron and with the C.S.I.R., Dr. Tillyard will probably be remembered mainly as a great protagonist for biological control of plant and insect pests, and as the author of two valuable text-books : " The Biology of Dragonflies " and " The Insects of Australia and New Zealand ". By his passing, Australia has lost a national figure, and we tender to Mrs. Tillyard and her daughters our deepest sympathy in their time of bereavement.

Personal Notes

CANBERRA, F.C.T.

Dr. B. T. Dickson visited New Zealand in January to look into the swamp flax industry there on behalf of the C.S.I.R. He also attended the meetings of the A.N.Z.A.A.S. in Auckland during that period.

Dr. G. A. Currie also attended the Science Congress in New Zealand, and opened the symposium on " Weed Control ".

Mr. H. F. Smith, of the Genetics Section, C.S.I.R., who is at present in England studying statistical methods in plant breeding work, has tendered his resignation from the service of the Council.

NEW SOUTH WALES.

Dr. T. H. Harrison has been appointed Fruit Research Officer in the Federal Department of Commerce. He will be stationed in London, and will report on shipments of Australian fruit. Facilities for carrying out research work in co-operation with the British Food Investigation Board and the C.S.I.R. will be extended to him.

Mr. C. J. Magee is now engaged on a full-time investigation of " bunchy-top " and other banana diseases.

Mr. O. Perkman has recently been awarded a Farrer Scholarship. He will undertake research work on the inheritance of quality in wheat, acting as a liaison officer between the Chemistry and Plant Breeding branches of the Department of Agriculture.

VICTORIA.

Mr. A. J. Vasey has been appointed Administrative and Secretarial Assistant to the Chief of the Division of Animal Health, C.S.I.R.

Mr. L. R. Scharp has resigned from the Department of Agriculture to take up the position of Dairy Bacteriologist to the Australian Sunny South Services Pty. Ltd. Mr. G. Loftus Hills also has resigned to accept the position of Dairy Technologist with James Bell Pty. Ltd.

Recent appointments to the research staff of the Department of Agriculture include Messrs. T. W. Hogan, Assistant Entomologist, and B. F. McKeon, Science Field Officer.

Professor Wadham and Mr. J. S. Ballantyne were present at the Conference of Australian Universities held in Adelaide recently.

OTHER STATES.

Mr. W. A. T. Summerville, of the Queensland Department of Agriculture, recently returned after an absence of thirteen months, during which he visited horticultural and entomological research institutions throughout the world.

Recent promotions in the Queensland Department include Mr. A. R. Brimblecombe as Assistant Entomologist, Mr. C. W. Winders as Assistant Agrostologist, and Mr. C. G. Hughes as Assistant Pathologist.

Mr. W. G. Wells, Director of Cotton Culture, Queensland Department of Agriculture, recently spent several weeks at the Waite Institute studying the technique employed in agronomic investigations.

Professors A. E. V. Richardson and J. A. Prescott, Messrs. C. S. Piper, A. W. Peirce, P. D. Hooper and Miss C. M. Eardley attended the Congress of the Australian and New Zealand Association for the Advancement of Science in Auckland, New Zealand.

Mr. E. F. Fricke returned to Tasmania last December, after spending a year studying grass-land problems in Europe and New Zealand.